Knowledge-Based Visualization of Multidisciplinary Databases for IDC Interactive Analysis: Region Specific and Global

Final Report
July 15, 1998

Sponsored by:
Advanced Research Projects Agency (DOD)
BMDO Order No. W2-6-B102500-01
Issued by U.S. Army Space and Strategic Defense Command

Grant No. DASG609610002

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Effective Date of Grant: 6/12/96
Grant Expiration Date: 6/10/98

Short Title:
Geological/Geophysical Database Development and Visualization

Reporting Period: 6/12/96-6/10/98

Distribution:

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DTIC QUALITY INSPECTED 1

19980831 041

AQ U98-11-2280

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	15 July 1998	Final Report (12 June 1996 - 10 June 1998)

4. TITLE AND SUBTITLE
Knowledge-Based Visualization of Multidisciplinary Databases for IDC Interactive Analysis: Region Specific and Global

5. FUNDING NUMBERS
Grant: DASG609610002

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Space and Strategic Defense Command
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P.O. Box 1500
Huntsville, AL 35807-3801

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Research sponsored by: Nuclear Treaty Programs Office
ATTN: Dr. Charles Meade 1901 N. Moore St., Suite 609
Arlington, VA 22209

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

A prototype Geographical Information System (GIS) with global coverage was developed at Cornell University in order to assist the Prototype International Data Center (PIDC) in merging the results of the four monitoring technologies (seismic, hydroacoustic, infrasound, and radionuclide) and to assist in ongoing calibration and location studies during the implementation of the Comprehensive Test Ban Treaty (CTBT). This system is intended to expand the PIDC's capabilities to include the use of non-seismic databases in an interactive way to serve the objectives of the CTBT verification readiness efforts. The GIS provides a rapid analysis tool to assist in discrimination of nuclear from non-nuclear events by placing suspect events in spatially registered displays of diversified, digital databases. These databases include topography, bathymetry, geology, tectonic zones, faults, seismicity, focal mechanisms, velocity and attenuation models, crustal thickness models, depth to metamorphic basement models, cultural landmarks, and Landsat imagery. The system permits rapid access to all data and graphical fusion of these data with the PIDC results using a simple menu-driven analysis tool and the data are also used for research directed at regional calibration of seismic events. The data may be viewed both internally and over the World Wide Web using commercially available, free GIS software (e.g., ArcExplorer).

14. SUBJECT TERMS					15. NUMBER OF PAGES
Global	Moho	Geographic Information System		WWW	
North Africa	Middle East	Geology	Russia	Satellite Imagery	16. PRICE CODE
Crustal Structure	Seismology	Geophysics			

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Limited

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1.0 Introduction

A prototype Geographical Information System (GIS) with global coverage was developed at Cornell University in order to assist the Prototype International Data Center (PIDC) in merging the results of the four monitoring technologies (seismic, hydroacoustic, infrasound, and radionuclide – Figure 1). This system is intended to expand the PIDC's capabilities to include the use of non-seismic databases in an interactive way to serve the objectives of the unilateral CTBT verification readiness efforts and to assist in ongoing calibration and location studies during implementation of the Comprehensive Test Ban Treaty (CTBT). The GIS provides an analysis tool to assist in discrimination of nuclear from non-nuclear events by placing suspect events in spatially registered displays of diversified, digital databases. These databases include topography, bathymetry, geology, tectonic zones, faults, historical seismicity, focal mechanisms, velocity and attenuation models, crustal thickness models, depth to metamorphic basement models, cultural landmarks, and Landsat imagery. The system permits rapid access to all data and graphical fusion of these data with the PIDC results using a simple menu-driven analysis tool and the data are also useful for research directed at regional calibration of seismic events. The data may be viewed both internally and over the World Wide Web using commercially available, free GIS software (e.g., ArcExplorer).

All available geological, geophysical, and imagery databases must be fused with data products produced at the PIDC to better calibrate a given region and for improved location of events. Such data are also useful for event verification, and discrimination between nuclear explosions and other types of similar events such as mine blasts or collapses, rock bursts, large chemical explosions, or anomalous seismic events. Work completed under this grant creates a state-of-the-art information system with simple data access tools. This system permits researchers, analysts, and possibly On-Site Inspection (OSI) teams to analyze, interpret, visualize, map, graphically manipulate and merge the results of multi-dimensional, multi-technology databases produced at the PIDC with non-seismic databases. These tools will directly access on-line digital databases to facilitate analyses of suspect events and to assist in associating such events to specific geologic structures or man-made facilities. Fusing PIDC products with GIS data will assist the monitoring effort by providing interactive access to global velocity and attenuation characteristics that will improve travel time and wave propagation calibration for any given region. Crustal and basement thickness and velocities will assist in accurate relocation of suspect events and rapid association of such events to known seismogenic zones, mines, topographic fronts, or known facilities.

Throughout this grant, collaborative research was also conducted between Cornell and PIDC researchers Vlad Ryaboy and Robert North. The resulting products added to the Cornell database include depth-to-basement, crustal thickness, crustal velocity, and uppermost mantle velocity grids for Russia. Additionally, crustal thickness, crustal velocity, and uppermost mantle velocity grids were created for the United States in order to assist in calibration efforts. A special database of all available geologic, geophysical, geographical, and imagery databases was also completed for the Novaya Zemlya region of Russia in order to analyze a specific event that occurred in the Kara Sea.

2.0 Digital Database Development for the Prototype International Data Center

This work creates a prototype, Geographical Information System (GIS) with associated geological, geophysical, geographical, and imagery databases accessible through an icon-driven graphical user interface (GUI). The purpose of this work is to provide the Prototype International Data Center (PIDC) multi-dimensional, multi-technology global databases with the necessary intelligent data access tools required to analyze, interpret, visualize, map, graphically manipulate, and interactively query the data.

2.1 Data Visualization

2.1.1 Data Format

Databases included in the Cornell GIS system were developed using ArcInfo GIS database management software. This GIS software is commercially available through Environmental Systems Research Institute (ESRI) at **http://www.esri.com**. The proprietary format includes several data types including point, line, polygon, grid, or image data. For this release of the Cornell GIS database, vector databases are preserved in their original ArcInfo format, but grids were converted to band interleaved line (bil) format for viewing in ArcExplorer. All grids were also converted to ASCII files for direct input to modeling programs or rapid conversion to ArcInfo grids for those users who have access to ArcInfo (can be converted using the **asciigrid** command).

2.1.2 Data Access and Visualization

The databases included in the system are organized on two CDROMs into four general directories: geographic, geologic, geophysical, and imagery (Figure 2 and Appendix A). The first CD contains global and regional geographical, geologic, geophysical data, project files, metadata, and ArcExplorer installation files. The second CD contains Thematic Mapper imagery data for nuclear test sites in the United States, Russia, Algeria, China, and Kazakstan and the International Seismological Centre (ISC) seismicity database. These databases are all designed to be accessed with ESRI's ArcExplorer GIS database viewer (Figure 3a) using pre-configured project files. Project files (files with an ".aep" extension) contained in the "Projects" folder of each CD provide simple views of all of the data included in this release of the Cornell database. The ArcExplorer GUI includes icon-driven tools that permit the user to open, save, and print views of the data. The user can rapidly zoom to any portion of the database, pan, and zoom out. Additionally, the user may create their own projects with ArcExplorer to display those databases pertinent to the problem under consideration. ArcExplorer also includes, a feature identify and extract data icon (Figure 3b), a

simple-to-use search engine for finding specific features in the data (Figure 3c), and a query builder that permits spatial analysis of databases (Figure 3d). Additionally, the user can optionally use the "Map Tips" icon (right most icon of Figure 3a) to automatically display a specific attribute as the mouse pointers is positioned over any point, line, or polygon. This GUI also permits the user to modify the display by changing the theme properties. Data can be displayed as single symbols (default), sorted by an attribute (unique value), sorted into classes (class breaks), or displayed with text from any field. The user is encouraged to read the on-line help available with ArcExplorer before experimenting with or attempting to change existing projects in the "Projects" folder. ArcExplorer is designed for use on a Windows NT/Windows compatible personal computer. The ArcExplorer installation file (aesetup.exe) is found in the ArcExplorer subdirectory on CDROM1 or is available directly from ESRI at **http://www.esri.com**.

2.2 Databases

For the following database description, capital letters are used to denote specific attributes pertinent to understanding a coverage without reading the entire metadata file.

2.2.1 Geographic Data

Cities

The cities (DCW, 1992) are displayed using the cities.aep project where the cities can be classified by unique values describing the type of city. The project is designed such that the "Map Tip Field Selection" displays the city name annotation when the mouse is located over a point. This database is displayed separately from other geographic data because the coverage contains over 200,000 points. The point symbols can be sorted by unique values that correspond to codes 1-5 for the TYPE attribute found in the cities.pat (.pat = point attribute table). The cities are labeled in the legend as Pop. Place (TYPE code 1), Urban Area (TYPE code 2), Village (TYPE code 3), Small Village (TYPE code 4), and Circular Village (TYPE code 5). *Cautionary note: Use the city coverage only in zoom mode, otherwise the large number of points will dominate the view.* Full documentation for these data can be viewed using the metadata.html file in the Metadata directory located on CD 1.

Coastlines and Borders

Coastlines, country borders, state borders and lake boundaries are displayed in four separate projects. High resolution coastlines (200 meter resolution from the NOAA database) and country borders are displayed in the coastline.aep project. The arcs for the high resolution coastlines are

displayed in green over the lower resolution country borders that are displayed in black. The high resolution database also includes lake boundaries and streams. A similar project that displays lower resolution (~1 km) state and inter-country state borders is found in the country_borders.aep project. Lastly, a polygon coverage that simply separates land from major water bodies is displayed with the Land_Ocean.aep project. The polygon symbols for the land-ocean correspond to the codes 1 or 2 for the POLNTYPE attribute found in the coast.pat (pat = point attribute table). A separate link is included in the project that permits the user to turn on/off the lakes attribute. Lakes are displayed in the Lakes.aep project using lakes.pat for the polygons. The lakes coverage contains ~1000 polygons that delineate lakes throughout the world. The area and perimeter of the lakes are contained in the attribute file of the coverage, but no other attributes are listed. Full documentation for these data can be viewed using the metadata.html file in the Metadata directory located on CD 1.

Roads and Railroads

The roads are displayed in the Roads.aep project with the coverage containing over 2.8 million arcs. For rapid viewing, the roads are displayed by using a single value that does not differentiate by the type of road. Attributes are included in the dataset that describe the type of road (RDTYPE) and status of the road (RDLINE). Road types are separated as dual lane (RDLNTYPE = 1), primary and secondary road (RDLNTYPE = 2), track, trail, or footpath (RDLNTYPE = 3), or road connector (RDLNTYPE = 8). The road status is assigned an attribute with roads described as functioning (RDLNSTATUS = 1), under construction (RDLNSTATUS = 2), reported to exist (RDLNSTATUS = 3), and schematic or connector only (RDLNSTATUS = 4,5,6, and 9). The railroads are displayed in the Railraods.aep with a coverage that contains over 114000 arcs. Attributes describe the type of track (RRLNTYPE) and operational status (RRLNSTATUS). Railroad types are separated as single track (RRLNTYPE = 1), multiple track (RRLNTYPE = 2), light duty (RRLNTYPE = 3), or railroad connector (RDLNTYPE = 8). The road status is assigned an attribute with roads described as functioning (RRLNSTATUS = 1), non-operating, abandoned, or destroyed (RRLNSTATUS = 2), reported to exist (RRLNSTATUS = 3), and schematic or connector only (RDLNSTATUS = 4,5,6, and 9). *Cautionary note: Use the roads and railroads coverages only in zoom mode, otherwise the large number of arcs will dominate the view.* Full documentation for these data can be viewed using the metadata.html file in the Metadata directory located on CD 1.

Nuclear Power Plants

Nuclear power plants are displayed in the Nuclear_test.aep project (Figure 4) that displays the nuclear_plants coverage. These data were obtained form the International Atomic Energy Agency, Vienna, Austria. The coverage contains the location, operating company (COMPANY), name (PLANTNAME), country/state (COUNTRY/STATE), reactor model (MODEL), power output (NETPOWER), type of reactor (POWERTYPE), start month (STARTMONTH), start year (STARTYEAR), operational status (STATUS), stop month (STOPMONTH - if applicable), and stop year (STOPYEAR - if applicable). Full documentation for these data can be viewed using the metadata.html file in the Metadata directory located on CD 1.

Nuclear Tests

Nuclear weapons test data for the United States, Britain, China, France, and the Former Soviet Union for the period 1946-1974 (Bolt, 1976) are displayed in the Nuclear_test.aep project. The nuclear test database includes 541 tests at ~21 locations with attributes describing the type of blast (BLAST_TYPE – ground, surface, air), country (COUNTRY), date (DATE), depth of burial in meters (DEVISE_DEPTH_M), location (LOCATION), magnitude (MAGNITUDE), remarks, surface elevation in meters (SURFACE_ELEV_M), test name (TEST_NAME), time of day in hours, minutes and seconds (TIME), weapon yield (YIELD), and general yield category (YIELD_CAT – megaton, intermediate, kiloton etc.).

Station Locations

Station locations are displayed in the Stations.aep project. This project includes station locations (seismic, hydroacoustic, radionuclide, infrasound, and radionuclide laboratories) from the proposed International Monitoring System (IMS – see Figure 1) as well as seismic stations locations from other countries and the International Seismological Centre (ISC). IMS stations are displayed using green triangles for the primary and auxiliary 3-component stations(primary stations are larger), green circles for the primary and auxiliary 3-component arrays (primary arrays are larger), maroon diamonds for the infrasound stations, red boxes for the radionuclide sampling stations, red inverted triangles for the radionuclide isotope sampling laboratories, purple crosses for the hydroacoustic stations with hydrophones, magenta crosses for the hydroacoustic stations with T-phase sensors. Seismic station locations for Algeria, Israel, Jordan, Morocco, Saudi Arabia, Syria, Turkey and broadband station locations for Africa and portions of Europe are also included in the seismic_stations.aep project (Figure 5). Station locations for the ISC are included but not displayed because the large number of stations would dominate the global

view. Full documentation for these data can be viewed using the metadata.html file in the Metadata directory located on CD 1.

2.2.2 Geologic Data

Africa, Middle East, and South Asia Geology

Digital geologic data for Africa, the Middle East, and South Asia are displayed in the Af_me_sa.aep project (Figure 6). This database includes geology, geologic provinces, and oil and gas fields for Africa (Persits et al., 1997), the Arabian Peninsula (Pollastro et al., 1998), and South Asia (Wandry and Law, 1998). These data were extracted from newly published USGS Open File Reports (OPFs 97-470A, 97-470B, and 97-470C). The data for Africa were compiled from 1:5,000,000 UNESCO geologic maps and include geologic, tectonic, and some offshore data. The data for the Arabian Peninsula were compiled from a USGS 1:2,000,000 geologic map of the Arabian Peninsula with additional data from 1:5,000,000 UNESCO maps of Iraq, Jordan, Syria, Israel, and Lebanon. The data for south Asia were compiled from 1:5,000,000 UNESCO geologic maps. These data are displayed with polygons color-coded based on age using a simplified color scheme. The actual polygon boundaries are not displayed because there is more detail in these data than the simplified view presents. For detailed analyses, the user should zoom to a location and use these data with the polygon outlines displayed (can be modified under the "Theme Properties" dialog box). Metadata for these data are located in the CU_database/metadata/USGS geology directory.

Novaya Zemlya Geology and Tectonics

Faults and geology in the Barents Sea, Kara Sea, and Novaya Zemlya are displayed in the Novaya_Zemlya.aep project. Digital geologic and fault databases were derived from the 1:2,500,000 scale Russian geologic map (Anonymous, 1983) and a 1996 1:2,500,000 scale Russian tectonic map (Figure 7). The tectonic map was derived from near vertical reflection and refraction data, gravity modeling, Deep Seismic Sounding (DSS) and borehole data (Bogatsky et al., 1996). Documentation for the Novaya Zemlya can be found in the March 1998 monthly report of Barazangi and Steer (sent to the Nuclear Treaty Programs Office, Arlington, VA).

Global Geology

A global geology map at 1:35,000,000 scale is displayed in the Global_geo.aep project. The Generalized Geology Map of the World (Kirkham, 1995) is a highly simplified geologic map and fault database that can be displayed with attributes for age, general rock type, and name. For simplicity, the data are displayed using only seven time periods (Holocene, Mesozoic, Cenozoic, Paleozoic, PreCambrian, Proterozoic, and

Archean). These data are intended to provide a general framework displaying global distributions of geologic patterns. The project also displays a global fault coverage that was included with the original data. This database is not intended for detailed analysis of a region. Full documentation for these data can be viewed using the metadata.html file in the Metadata directory located on CD 1.

Middle East Geology and Tectonics

The geology and tectonic map of the Middle East and North Africa is displayed in the Middle_East-North_African_ Tectonics.aep project. These data were compiled by the Cornell GIS group based on several years of detailed research in the Middle East and North Africa (Seber et al., 1997). This specialized database includes known Holocene volcanoes in the region (volcanoes.pat), North Africa volcanic outcrops (NA_volcanics.aat), and North Africa depth-to-basement contours (NA_basement.aat). In addition it includes point locations used to compute the depth-to-basement (NA_basement.pat), North Africa faults (NA_faults.aat), Middle East volcanic outcrops (Basalt_basm.aat), Middle East depth-to-basement contours (Basem.aat), Middle East faults (faults.aat), and geology (basalt.pat). Full documentation for these data can be viewed using the metadata.html file in the Metadata directory located on CD 1.

United States Geology and Tectonics

The geology and tectonic map of the United States is displayed with the United_States_geology.aep project. This database was digitized from the 1967-1971 Geologic Map of the United States by the USGS. This database includes attributes for the rock age, unit, rock description, and color code for plotting. These data were simplified for viewing in ArcExplorer by adding the attribute "system" to merge rock unit orders into five time periods (Quaternary, Tertiary, Mesozoic, Paleozoic, and PreCambrian). Faults are also displayed in the US_geology.aep. These faults are also digitized from the 1967-1971 Geologic Map of the United States by the USGS. Attributes for these faults include a condensed description of the fault for plotting, a detailed description of the fault for documentation, a line type and line symbol to distinguish the different types of faults (thrust, strike-slip, normal). An additional coverage named "High_Res.geology" displays all the polygons in the coverage, with no age-related color scheme. Full documentation for these data can be viewed using the metadata.html file in the Metadata directory located on CD 1.

Mine Locations

Mine locations for Algeria, Canada, Egypt, Eurasia (USGS and former US Bureau of Mines), Digital Chart of the World Global, Iran, Iraq, Israel, Jordan, Libya, Morocco, Syria, Tunisia, and Turkey are

displayed with the Mines.aep project (Figure 8). The attributes for these different databases vary. In general they include attributes describing the type of mine (PRODUCT or COMMODITY), location (CITY), mine name (MINE), operating organization (COMPANY). The global and regional datasets (Global DCW and Eurasia) are more limited in attributes. Individual countries have more detailed attributes such as rock type (TYPE), operating history (STATUS), host rock morphology (MORHOLOGY), markets (MARKET) and data references (REFERENCE). Full documentation for these data can be viewed using the metadata.html file in the Metadata directory located on CD 1. *Cautionary note: Use the mine coverage only in zoom mode, otherwise the large number of points will dominate the view.*

Volcanoes

A global database of volcanoes is displayed in the Global_volcanos.aep project (Figure 9). This database is a condensed and updated version of the Catalog of Active Volcanoes of the World with its time period expanded to include the past 10,000 years. The Global_volcanoes coverage includes attributes describing the elevation of the summit (ELEVATION), geographic location (LOCATION), volcano name (NAME), activity status (STATUS), and the type of volcano (TYPE). Full documentation for these data can be viewed using the metadata.html file in the Metadata directory located on CD 1.

2.2.3 Geophysical Data

Attenuation Data

An image of mean Lg Coda Q (Mitchell et al., 1997) for Eurasia is displayed in the eurasia_lg_coda_Q.aep project (Figure 10). These data are displayed as an image in ArcExplorer, but the data are also provided in gzip compressed ASCII format (eurasia_lg.ascii.gz). These data were derived using tomographic methods on an extensive set of regional broadband and short period seismograms of regional seismic events. Full documentation for these data can be viewed using the metadata.html file in the Metadata directory located on CD 1.

Basement Depth

Images of the depth-to-basement for a global dataset (Mooney et al., 1997), Asia (Ritzwoller et al., 1997), IPE (Institute of the Physics of the Earth) Eurasia (Kunin et al., 1987), the Middle East (Seber et al., 1997), Russia (GEON Center, 1997), and the Barents/Kara Sea region (Bogatsky et al., 1996) are included in this database release. These data are displayed in the global_basement, IPE_basement (Figure 11), middle_east_basement, geon_basement, and barent_sea_basement

projects. These datasets form a complete library of the digital databases of depth-to-basement available at this printing. The global database is a 5x5 degree compilation, the Asia database has 5 km resolution, the Middle East database has 5 km resolution, the IPE Eurasia database has 10 km resolution, the GEON Center derived Russia database has 10 km resolution, and the Barents/Kara Sea database has 1 km resolution. All databases are displayed as images with the data included as gzip compressed ascii files. Full documentation for the Asia, IPE Eurasia, and Cornell basement databases can be viewed using the metadata.html file in the Metadata directory located on CD 1. Documentation for the global, GEON Center derived Russian, and Barent/Kara Sea depth-to-basement databases can be found in the monthly reports of Barazangi and Steer (November, 1996, February, 1998, and March, 1998 respectively; sent to the Nuclear Treaty Programs Office, Arlington, VA).

Bathymetry and Topography

Bathymetry and topography are displayed as a geo-referenced tiff image in the Global_topo.aep project. This image was created from several topography and bathymetry databases that were merged into a single database and resampled to 1 km. Topography (1 km resolution) originates from the USGS GTOPO30 dataset, global marine bathymetry (3.7 km resolution) originates from the database of Sandwell and Smith (1996), and any regions with no data are filled using the USGS ETOPO5 topography and bathymetry (10 km resolution). Since this merged database is ~2GB, it is not included in the data release. Interested parties are encouraged to contact the Cornell GIS group directly for access to this merged dataset. Full documentation for these data can be viewed using the metadata.html file in the Metadata directory located on CD 1.

Crustal Thickness

Images of the crustal thickness for all datasets in the Cornell database are displayed in the moho.aep project (Figure 12). These include the following images and data files: eurasia_moho and corresponding error surface derived from several databases (Barazangi and Steer, 1998), global_moho (Mooney et al., 1997), Russia-Urals (GEON Center, 1997 and Bazhenov Geophysical Expedition unpublished data), Russia-NoUrals (GEON Center, 1997), IPE_Moho (Kunin et al., 1987), Middle_East_Moho (Seber et al., 1997), United_States_Moho and United_states(Error) (derived from Braile et al., 1989), and China/Asia (Ritzwoller et al., 1997). Individual projects are included that display single country/region databases (see project folder). These datasets form a complete library of the digital databases of crustal thickness available at this printing. The global database is a 5x5 degree compilation, the Asia database has 5 km resolution, the Middle East database has 5 km resolution, the IPE Eurasia database has 10 km resolution, the Russia

database has 10 km resolution, the combined Eurasia databse has 10 km resolution, and the Novaya Zemlya database has 1 km resolution. All databases are displayed as images with the data included as gzip compressed ascii files. Documentation for the global crustal thickness database, Russia crustal thickness, US crustal thickness, and the combined Eurasia crustal thickness can be found in the monthly reports of Barazangi and Steer (November, 1996, January 1997, and February, 1998 respectively; sent to the Nuclear Treaty Programs Office, Arlington, VA). Full documentation for the Asia, IPE Eurasia, and Cornell basement data can be viewed using the metadata.html file in the Metadata directory located on CD 1.

Gravity Data

Free Air and Bouguer gravity data images for the Middle East, North Africa are displayed in the Africa_middle-east_gravity.aep project, and those for North America in United_States_gravity (bouguer only). The gravity data for the Middle East and North Africa are derived from a contour map of Syria (2.5 mgal contour interval) combined with a point dataset from the Defense Mapping Agency. The data for the United States and portions of North America are derived from the Geophysics of North American datasets (Hittelman et al., 1989) dataset (6 km cell size). All databases are displayed as images with the data included as gzip compressed ascii files. Full documentation for the Middle East and North Africa gravity databases are available using the metadata.html file in the Metadata directory located on CD 1. Metadata for the DNAG derived database is available in the CU_database/metadata/other/DNAG directory.

Magnetic Data

Magnetic data images for the United States are displayed in the United_States_magnetics.aep project. The data for the United States are derived from the Geophysics of North American datasets (Hittelman et al., 1989) dataset (2 km cell size). All databases are displayed as images with the data included as gzip compressed ascii files. Metadata for the DNAG derived database is available in the CU_database/metadata/other/DNAG directory.

Seismicity Catalogs

Three digital instrumental seismicity catalogs are included in this release of the Cornell database and are displayed using the Seismicity.aep project. The Prototype International Data Center Reviewed Event Bulletin (PIDC-REB) catalog includes over 70,000 events covering the period 1995-May 1998. These events include all attributes included in the PIDC REB (see the IDC_events.aep project). The Harvard Centroid Moment Tensor (CMT) catalog includes over 13,000 events covering the period 1977-1996. These events include all focal mechanism attributes

and are generally magnitude 5.5 and above (see the CMT.aep project). The International Seismological Center (ISC) database includes over 700,000 events covering the period 1964-1994. This database includes attributes describing the location, depth, magnitude, and detailed error analysis information (see the ISC.aep project on CDROM2). Since the ISC uses all available station information to re-locate events, this catalog is considered to be the authoritative source of global instrumental seismicity. *Cautionary note: Use the seismicity coverages only in zoom mode, otherwise the large number of points will dominate the view and can be very slow in plotting.*

Full documentation for the CMT and ISC databases are available using the metadata.html file in the Metadata directory located on CD 1. Full documentation for the REB database is available at **http://www.cdidc.org**.

Velocity Data

Images of the crustal (Pg and Sg) and upper mantle (Pn and Sn) velocity for a global dataset (Mooney et al., 1997), Russia (GEON Center, 1997), and the United States (Pn) (Braile et al., 1989) are displayed in the Velocity.aep project. All databases are displayed as images with the data included as gzip compressed ascii files. Documentation for the global velocity database and Russia velocity can be found in the monthly reports of Barazangi and Steer (November, 1996 and February, 1998 respectively; sent to the Nuclear Treaty Programs Office, Arlington, VA).

World Stress Data

Point data having attributes describing contemporary tectonic stress in the crust are displayed with the World_stress.aep project. These data are derived from the World Stress Map of Zoback and Zoback (1980). The stress indicators were determined using focal mechanisms, well bore breakouts, in-situ stress measurements, and young geologic data. The coverage with these data includes attributes describing the orientation of the primary stress vector (AZIMUTH), a data quality ranking (QUALITY), a stress regime (REGIME), location information, method of determining the value and orientation (METHOD), and rock type information. Points are displayed in the project using the regime attribute to differentiate symbols (TF: thrust faulting, TS: thrust with strike-slip component, SS: strike-slip, NS: normal with strike-slip component, NF: normal faulting, U: unknown, largely breakout data). Full documentation for these data can be viewed using the metadata.html file in the Metadata directory located on CD 1.

2.2.4 Imagery

Imagery data for the United States Nevada Test Site, Novaya Zemlya, Lop Nor, Hoggar Mountains of Algeria, and Semipalatinsk are

displayed on the Imagery CD using the *site*_imagey.aep project file (where *site* is replaced by the appropriate test site – e.g. For the Nevada Test Site open Nevada_imagery.aep). These scenes are displayed as full resolution (30 m) three band interleaved line (bil) images geographically referenced in the Transverse Mercator Projection. Latitude and longitude markers are included for each image. The Nevada data were registered to the 30-meter resolution USGS digital elevation model data. The scenes in Asia and North Africa were registered using the 90-meter resolution digital elevation model of the Defense Mapping Agency. Full resolution, geographically referenced, seven band images were not included in this release of the Cornell database due to file size limitations. Documentation for the imagery databases can be found in the November 1997 monthly report of Barazangi and Steer (sent to the Nuclear Treaty Programs Office, Arlington, VA).

3.0 Metadata

Full documentation for all data is included on CD 1 in the Metadata directory (in HTML format) except where noted in specific database descriptions. Additionally, documentation for the global depth-to-basement database and Russia depth-to-basement can be found in the monthly reports of Barazangi and Steer (November, 1996 and February, 1998 respectively; sent to the Nuclear Treaty Programs Office, Arlington, VA). Documentation for the global crustal thickness database, Russia crustal thickness, US crustal thickness, and the combined Eurasia crustal thickness can be found in the monthly reports of Barazangi and Steer (November, 1996, January 1997, and February, 1998 respectively; sent to the Nuclear Treaty Programs Office, Arlington, VA). Documentation for the global velocity database and Russia velocity can be found in the monthly reports of Barazangi and Steer (November, 1996 and February, 1998 respectively; sent to the Nuclear Treaty Programs Office, Arlington, VA). Documentation for the imagery databases can be found in the November 1997 monthly report of Barazangi and Steer (sent to the Nuclear Treaty Programs Office, Arlington, VA).

4.0 Recommended System

It is the Cornell GIS group recommendation that the PIDC adopt an ArcInfo menu driven GIS system for use as a geological, geophysical, and geographic database analysis and visualization system (Figure 13). A menu-driven GIS similar to that already developed at Cornell can easily be modified to suit the internal needs of the PIDC for special event analysis or to provide additional information about a particular event to requesting agencies. A commercially available spatial database engine (SDE) for ORACLE could also fully integrate this system with the PIDC database to provide direct access, query, and display of any spatial data and attributes stored in the database schema. Tools can easily be added that will provide simple access to the data by researchers at the

PIDC. A World Wide Web map server to serve the broader research community can also easily be added to the system.

In order to implement the fully functional system described in Figure 13, the PIDC must purchase ArcInfo and/or ArcView, the ORACLE spatial database engine (SDE), and the Internet Map Server software. For rapid access and analysis, the system requires a minimum of a Unix (or Solaris) based machine with 23 GB of on-line storage. The update and maintenance of this system will require one person familiar with GIS and ORACLE systems working ~ 1/2 time. Cornell personnel will assist in the initial installation and training of personnel maintaining and using the ArcInfo menu-driven system. A menu-driven GIS similar to that already developed at Cornell can easily be modified to suit the internal needs of the PIDC for special event analysis or to provide additional information about a particular event to requesting agencies. A commercially available spatial database engine (SDE) for ORACLE can also fully integrate this system with the PIDC database to provide direct access, query, and display of any spatial data and attributes stored in the database schema. Tools can easily be added that will provide simple access to the data by researchers at the PIDC. A World Wide Web map server to serve the broader research community can also easily be added to the system. The PIDC data products can be integrated with and complemented by global databases distributed with this report or those under development at Cornell.

5.0 Conclusions

The database product distributed with this report is intended to serve as an interim GIS database viewer for the PIDC. A fully functional GIS using the Cornell menu system and ArcInfo will permit computational and visual spatial analysis and query of data attributes for any geographically registered data in the system. It can be effectively used to make a detailed analysis of an event. Cornell recommends that the PIDC adopt an ArcInfo based, menu-driven GIS that is fully compatible with the IDC Oracle database through a commercially available spatial database engine that also has a public Web access option to provide the most useful, functional, and flexible GIS system for the PIDC. Once the required software is procured, Cornell researchers can assist the PIDC in installing the Cornell menu-driven system.

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Appendix A: Directory structure and project files.

CDROM 1

CDROM1 contains one master directory CU_Database in which all the data and projects are stored. The CDROM is divided into five directories; geography, geology, geophysics, projects, and metadata. The data coverages are stored in the geology, geophysics, and geography directories. Each data directory contains subdirectories in which the coverages are stored. All the project files are stored in the project directory which contains subdirectories for different types of projects. This appendix outlines the contents of the directories, subdirectories and project files contained on the CDROMs and includes a brief description of the coverages in the subdirectories. Detailed descriptions of these databases are located in the metadata directory (in html and/or text format).

CU_Database

Geography

Borders
Cities
Coastline
Lakes
Roads
Railroads
Nuclear_power_plants
Nuclear_tests
Seismic_stations

Geology

Africa
Middle_East
Novaya_Zemlaya
Global
High_Resolution_middle_east
United_states
Mines
Volcanoes
Faults

Geophysics

Attenuation
Basement
Bathymetry
Topography
Crustal_thickness
Gravity
Magnetics
Velocity
Crustal_stress
Seismicity

Projects

Geographic
Geologic
Geophysics
Multiple_Datasets

Metadata

Metadata.html
Metadata
USGS geology

Geography

-borders

-borders

countries_geo = a low resolution coverage of country borders included in all project files.

-ponet = This is a high resolution (1:1,000,000 scale) dataset from the Digital Chart of the World. Arcs indicate political and ocean boundaries. "The political/oceans coverage provides a common visual definition of countries rather than a legal one. The legal definition of a coastal country would include offshore ocean areas, while with a graphic depiction, the country ends at the ocean shoreline. Please note that the ocean shoreline is included in the political/oceans line coverage only and is not repeated in the drainage coverage (dnline). This type of feature organization enables selection of countries as areas and the distinction of the land and water areas of the world." (ESRI Dictionary.)

-Cities

cities = This Digital Chart of the World coverage contains locations of urbanized areas (built-up areas) of the world.

-Coastline

coast-ae = Modified version of the ponet coverage (deleted lat/lon lines and non-essential boundaries).

hr_coast_dd = high resolution coastline obtained from the NOAA Global Self-consistant Hierarchical High-resolution Shorelines database.

-Lakes

lakes = This is a low resolution (resampled) dataset from the Digital Chart of the World. Polygons indicate regions of inland water, ice, or wet sand.

-Roads

roads = This is a high resolution (1:1,000,000 scale) dataset from the Digital Chart of the World. Arcs indicate roads.

-Railroads

Rroads = This is a high resolution (1:1,000,000 scale) dataset from the Digital Chart of the World. Arcs indicate railroad lines. Further information on this dataset can obtained from http://atlas.geo.cornell.edu

-Nuclear _Power_Plants

Nuc_plant = This dataset contains the locations of nuclear power plants worldwide, along with their operational status, type, model, power output, and start/stop dates.

-Nuclear _tests

nuclear_test = Contains data about nuclear tests conducted by France, Great Britain, China, the U.S., and the U.S.S.R. prior to about 1973.

-Seismic Stations

alg_sta = The coverage contains station locations of seismic stations in Algeria.

bb_stns = This is a dataset of broad band seismic stations in Africa and Europ compoiled from several networks, containing information about their location, instrumentation, and dates of operation.

ims_stns = The coverage includes locations and characteristics of all stations in the International Monitoring System (IMS). There are four station types: seismic, radionuclide, hydroacoustic, and infrasound.

israel = The coverage contains station locations of the national seismic network.

isc_stations = This dataset contains the ID code, location, elevation, and dates of operation for all seismological stations which reported data to the International Seismological Centre (ISC) for any portion of the period 1964-1994.

jordan = The coverage contains station locations of the national seismic network.

morocco = Dataset consists of the Moroccan National Seismic Network short period station locations.

saudi = The coverage contains station locations of the national seismic network.

syria = Dataset consists of the Syrian National Seismological Centers short period station locations.

turkey = Dataset consists of the Turkish National Seismic Network short period station locations.

Geology

-Africa

Na_basement = The dataset contains the location of North African basement outcrops.

Na_faults = The dataset contains faults, flexures, fissures, and plate boundaries of North Africa. Faults are described in terms of fault type, fault length, level of activity and quality of data.

Na_volcanics = The dataset contains the location of volcanics in North African bedrock.

-Middle_East

Basalt_basm = The dataset contains basement outcrops, ophiolites, volcanics, and depressions in the Middle East.

Basm_depth = he coverage is a contour map of the depth to basement in the Middle East, with 500-m contour interval.

Faults = The dataset contains faults, flexures, fissures, and plate boundaries of the Middle East. Faults are described in terms of fault type, fault length, level of activity and quality of data.

ME_volcanoes = The dataset contains volcano locations in the Middle East.

-Novaya_Zemlya

Bar_tect = Barent Sea Tectonics coverage

Nov_geol = Novaya Zemlya Geology coverage

Images = bill files of basement and bathymetry in the vicinty of Novaya Zemlya.

-Global

World_dd = The Generalized Geology of the World is a highly simplified digital geological data set composed of geographically referenced rock unit patchworks and fault lines which can be combined with tables of descriptive data.

-High_Resolution_Middle_East

afr_me_india = Coverage displaying 1:5,000,000 scale geology of Africa, the Middle East, and South Asia that was derived from USGS distributed databases.

-United_States

Usgs_fault = In 1974 the U.S. Geological Survey published a new Geologic Map of the United States (exclusive of Alaska and Hawaii) on a scale of 1:2,500,000, which was compiled between 1967 and 1971 by Philip B. King and Helen M. Beikman, with geologic cartography by Gertrude J. Edmonston.

Usgs2_geo = In 1974 the U.S. Geological Survey published a new Geologic Map of the United States (exclusive of Alaska and Hawaii) on a scale of 1:2,500,000, which was compiled between 1967 and 1971 by Philip B. King and Helen M. Beikman, with geologic cartography by Gertrude J. Edmonston.

-Mines

algeria = Mine of Algeria from DOE reports.

Canada = The dataset contains locations and commodities of the principal producing mines of Canada.

Egypt = The dataset contains the name, location, producing status, commodity, type of mining method, and markets (foreign or domestic) for mine products within Egypt, along with data reliance and data references.

Eurmines_usgs = Eurasian mines, selected data on worldwide mines from the USGS Mineral Resources Data System (MRDS) database of worldwide mines, current as of 10/1/93, including mine type, location, and producing status.

Eurmines_usbm = Eurasian Mines, data from non_USA mines, mills, and processing plants, taken from the US Bureau of Mines Minerals Availability System (MAS) database.

Gmines_dcw = This Digital Chart of the World coverage contains mine locations.

Israel = The dataset contains the name and producing status of mines in Israel.

Iran-a = The dataset contains the name, location, producing status, commodity, type of mining method, and markets (foreign or domestic) for mine products within Iran, along with data reliance and data references.

Iran-b = The dataset contains the name, location, producing status, commodity, type of mining method, and markets (foreign or domestic) for mine products within Iran, along with data reliance and data references.

Iraq = The dataset contains the name, location, producing status, commodity, type of mining method, and markets (foreign or domestic) for mine products within Iraq, along with data reliance and data references.

Jordan = The dataset contains the name, location, producing status, commodity, type of mining method, and markets (foreign or domestic) for mine products within Jordan, along with data reliance and data references.

Libya = The dataset contains the name, location, producing status, commodity, type of mining method, and markets (foreign or domestic) for mine products within Libya, along with data reliance and data references.

Morroco = This dataset contains mine locations, commodities, and host rock descriptions of mines in Morocco, as tabulated by the Moroccan Ministry of Energy and Mines. All attribute records are in French.

Syria = The dataset contains the name, location, producing status, commodity, type of mining method, and markets (foreign or domestic) for mine products within Syria, along with data references.

Tunisia = The dataset contains the name, location, producing status, commodity, type of mining method, and markets (foreign or domestic) for mine products within Tunisia, along with data reliance and data references.

Turkey = The dataset contains the name, location, producing status, commodity, type of mining method, and markets (foreign or domestic) for mine products within Turkey, along with data reliance and data references.

-Volcanoes

gvolcanoes = This dataset is basically a condensed and updated version of the Catalog of Active Volcanoes of the World_ (CAVW), but with its time frame expanded to 10,000 years. It contains the geographic data, morphology, activity status, and known eruptive history of 1,489 volcanoes.

-Faults

Global_flts = fault coverage derived from the Generalized Geology of the World database.

Geophysics

Attenuation

NOTE: All images described below have a common file structure. The original grid is included as an ascii text file XXX.ascii (XXX represents the file name) with an accompanying projection file (XXX no extension). Other files are created when converting the grids to images (XXX.bil – image file, XXX.hdr – header file, XXX.blw – map limits, XXX.stx – internal file, XXX.clr – co,or mapping file).

Eurasia

Eurasisa-lg-coda-Q = An extensive set of broadband and short-period seismograms from regional seismic events has been used to derive a tomographic image of broad-scale variations of Lg coda Q for most of Eurasia.
Eurasisa-lg-coda-Q.ascii
Eurasisa-lg-coda-Q.hdr
Eurasisa-lg-coda-Q.bil
Eurasisa-lg-coda-Q.blw
Eurasisa-lg-coda-Q.clr
Eurasisa-lg-coda-Q.stx
Eurasisa-lg-coda-Q

Basement

Global = Database derived from the USGS CRUST5.1 database of Mooney et al., 1997.
Global_basm.ascii
Global_basm.bil
Global_basm.blw
Global_basm.hdr
Global_basm
Global_basm.stx

IPE_Basement = Shows the depth to basement in the Middle East and North Africa, based on a contour map from the Institute of Physics of the Earth, Moscow.
ipe_basm.stx
ipe_basm.ascii
ipe_basm.bil
ipe_basm.blw
ipe_basm.clr

ipe_basm.hdr
ipe_basm

Middle_East = The database contains estimated depth to basement in the Middle East.
Middle_East_basement.ascii
Middle_East_basement.stx
Middle_East_basement.bil
Middle_East_basement.blw
Middle_East_basement..clr
Middle_East_basement..hdr
Middle_East_basement.

Novaya Zemlya
Nz_bsmt_dd.ascii
Nz_bsmt_dd

Crustral_Thickness

China = Surface wave dispersion was used to model the depth to Moho in central Asia.
China_moho.stx
china_moho.ascii
china_moho.bil
china_moho.hdr
china_moho.blw
china_moho.clr

Eurasia

eurasia_Error = error surface of eurasia_moho (output from kriging algorithm used to generate grid).
eurasia_Error.stx
eurasia_Error.bil
eurasia_Error.blw
eurasia_Error.hdr
eurasia_Error.clr
eurasia_Error.asii
eurasia_Error

eurasia_moho = Image of Eurasia crustal thickness derived from merging the highest quality data for the entire region.
eurasia_moho.stx
eurasia_moho.bil
eurasia_moho.blw
eurasia_moho.clr
eurasia_moho.hdr
eurasia_moho.ascii
eurasia_moho

Global

Global_moho = Database derived from the USGS CRUST5.1 database of Mooney et al., 1997.
global_moho..ascii
global_moho.stx
global_moho.hdr
global_moho.bil
global_moho.blw
global_moho.clr

global_moho

IPE

IPE = The dataset shows the depth to Moho in the Middle East and North Africa, based on a contour map from the Institute of Physics of the Earth, Moscow.

Ipe_moho.ascii
ipe_moho.sxt
ipe_moho.hdr
ipe_moho.bil
ipe_moho.blw
ipe_moho.clr
ipe_moho

Middle_East

Middle_East = Moho map of the Middle East from Seber et al., 1997.

Middle_East.ascii
Middle_East.bil
Middle_East.hdr
Middle_East.blw
Middle_East.clr
Middle_East.stx

Russia

Russia(no_Urals)= Moho in Russia generated with a blocking algorithm such that no interpolation occurred over the Ural mountains where there were no data in the GEON maps.

Russia(no_Urals).ascii
Russia(no_Urals).bil
Russia(no_Urals).blw
Russia(no_Urals).hdr
Russia(no_Urals).clr
Russia(no_Urals).stx
Russia(no_Urals).

Russia_moho= Moho in Russia generated from GEON maps with interpolation across the Urals.

Russia_moho.ascii
Russia_moho.stx
Russia_moho.hdr
Russia_moho.bil
Russia_moho.blw
Russia_moho.clr
Russia_moho.

Russia-Urals_moho= Moho in Russia generated from GEON maps combined with data for the Urals from the Bazhenov Geophysical Expedition, Russia.

Russia-Urals_moho.ascii
Russia-Urals_moho.stx
Russia-Urals_moho.hdr
Russia-Urals_moho.bil
Russia-Urals_moho.blw
Russia-Urals_moho.clr
Russia-Urals_moho

United_States

United_States(Error)= Error surface for the US Moho grid derived from the work of Braile et al., 1989.
United_States(Error).ascii
United_States(Error).bil
United_States(Error).hdr
United_States(Error).blw
United_States(Error).clr
United_States(Error).stx
United_States(Error)

United_States_moho = US Moho grid derived from the work of Braile et al., 1989.
United_States_moho.ascii
United_States_moho.hdr
United_States_moho.bil
United_States_moho.blw
United_States_moho.stx
United_States_moho.clr
United_States_moho

Gravity

Africa_Middle-East

Afr_boug = The dataset describes the Bouguer gravity anomaly field in the Middle East and North Africa.
Afr_boug.bil
Afr_boug.stx
Afr_boug.hdr
Afr_boug.blw
Afr_boug.ascii
Afr_boug
Afr_boug.clr

Afr_fair = The dataset describes the free air gravity anomaly field in the Middle East and North Africa.
Afr_fair.bil
Afr_fair.blw
Afr_fair.hdr
Afr_fair.stx
Afr_fair.ascii
Afr_fair.clr
Afr_fair.

United States Gravity = Grid of the DNAG gravity database for North America (6km resolution).
Dnag_grav.bil
Dnag_grav.blw
Dnag_grav.clr
Dnag_grav.ascii
Dnag_grav.hdr
Dnag_grav.
Dnag_grav.stx

Magnetics

United States Magnetics = Grid of the DNAG magnetic database for North America (2 km resolution).
Dnag_mag.hdr
Dnag_mag.bil

Dnag_mag.blw
Dnag_mag.clr
Dnag_mag.hdr
Dnag_mag.ascii
Dnag_mag.stx

Velocity

Russia

Russia_pg

Russia_pg_dd = coverage of russia pg from GEON maps.
Russia_pg_L.bil = image with lower velocity values.
Russia_pg_L.blw
Russia_pg_L.clr
Russia_pg_L.hdr
Russia_pg_L.stx
Russia_pg_low.ascii
Russia_pg_L.prj

Russia_pg_U.bil = image with upper velocity values.
Russia_pg_U.blw
Russia_pg_U.clr
Russia_pg_U.hdr
Russia_pg_U.stx
Russia_pg_up.ascii
Russia_pg_U.prj

Russia_pn

Russia_pn
Russia_pn_dd = coverage of russia pg from GEON maps.
Russia_pn_L.bil
Russia_pn_L.blw
Russia_pn_L.clr
Russia_pn_L.hdr
Russia_pn_L.stx
Russia_pn_low.ascii
Russia_pn_L.prj

Russia_pn_U.bil
Russia_pn_U.blw
Russia_pn_U.clr
Russia_pn_U.hdr
Russia_pn_U.stx
Russia_pn_up.ascii
Russia_pn_U.prj

US

Usapn10km = Coverage of US Pn velocity.
Us_pn.bil
Us_pn.blw
Us_pn.clr
Us_pn.hdr
Us_pn.stx
Us_pn.ascii
Us_pn.prj
Usapn10km.ascii

Usapn10km = coverage of US Pg velocity.
Us_pg.bil
Us_pg.blw
Us_pg.clr
Us_pg.hdr
Us_pg.stx
Us_pg.ascii
Us_pg.prj
Usapg10km.ascii

Crustal_Stress

WSM = The coverage contains information on contemporary tectonic stress in the crust. The World Stress map was originally based on the compilation of tectonic stresses for the United States by Mary Lou and Mark Zoback (Zoback and Zoback, 1980).

Seismicity

CMT-AE = The dataset contains location, time, and focal mechanism solutions for earthquakes 1977-1996 with surface wave magnitude greater than or equal to about 5.5 Solutions are found with the Harvard centroid-moment tensor (CMT) method, which uses long period surface and body wave modeling to estimate the optimum focal mechanism.

Hypo_dd = This coverage contains the 55,329 events in the Middle East and North Africa, 1964-1992, from the historical earthquake data in the Global Hypocenter database. It includes earthquake time, location, and magnitude, as well as information about related events, e.g. tsunami and liquefaction.

IDC_ev = National Data Centers (NDCs) submit seismic data to the International Data Centre (IDC) and provide expertise to assist in the processing of their data at the IDC. [Alpha stations, primarily arrays, submit continuous real-time data. Beta stations, primarily 3-component stations, submit data upon request.] The IDC prepares an Alpha Event list based on the Alpha station data and makes it available to the NDCs within approximately one hour after an event occurs. The IDC retrieves waveform segments from selected Beta stations and forms a combined Alpha and Beta Event List (ABEL) according to the requirements for location accuracy, with automated processing. The ABEL must be completed and made available to the NDCs within approxmiately four hours. An analyst then reviews these Event Lists and produces a bulletin (REB) within 48 hours.

ISC = This dataset contains epicenter information for earthquakes published in the International Seismological Centre (ISC) Bulletin in the years 1964 to 1994 (NOTE: Due to file size limitations, these data are located on CDROM2).

Projects	***Label***	***Coverage***	***Coverage Type***

Geographic

Cities.aep
- Country Borders = countries_geo = line coverage
- Cities = cities = point coverage

Coastline
- Country Borders = countries_geo = line coverage
- High Res = hr_coast_dd = line coverage

Country_Borders.aep
- Country Borders = countries_geo = line coverage
- State borders = coast-ae = line coverage (state borders)

Lakes.aep
Country Borders = countries_geo = line coverage
Lakes = lakes = polygon coverage

Land_ocean.aep
Country Borders = countries_geo = line coverage
Land-Ocean = ponet = polygon coverage
Lakes = lakes = polygon coverage

Nuclear_power_plants.aep
Country Borders = countries_geo = line coverage
Nuclear Power = nuc_plant = point coverage

Nuclear_tests.aep
Country Borders = countries_geo = line coverage
Nuclear Tests = nuclear_test = point coverage

Rail_roads.aep
Country Borders = countries_geo = line coverage
Railroads = rroads = line coverage

Roads.aep
Country Borders = countries_geo = line coverage
Roads = roads = line coverage

Seismic_Stations.aep
Country Borders = countries_geo = line coverage
Algeria = alg_stns = point coverage
Broadband = bb_stns = point coverage
IMS = ims-stns = point coverage
Israel = israel = point coverage
ISC = isc_stations = point coverage
Jordan = jordan = point coverage
Morocco = morocco = point coverage
Saudi Arabia = saudi = point coverage
Turkey = turkey = point coverage

Geologic

Africa_ME_SA_geology.aep
Country Borders = countries_geo = line coverage
High Resolution = afr_me_india = polygon coverage

Middle_East-North_African_tectonics.aep
Country Borders = countries_geo = line coverage
ME Basm Geology = basalt_basm = polygon coverage
ME Basement Depth = basm_depth = line coverage
ME Volcanoes = me_volcanoes = point coverage
ME faults = faults = line coverage
N. Afr. Volcanics = na_volcanics = line coverage
N. Afr. Faults = na_faults = line coverage

Mines.aep
Country Borders = countries_geo = line coverage
Algeria = Algeria = point coverage
Canada = Canada = point coverage

Egypt = Egypt = point coverage
Israel = Israel = point coverage
Irana = Irana = point coverage
Iranb = Iranb = point coverage
Iraq = Iraq = point coverage
Jordan = Jordan = point coverage
Libya = Libya = point coverage
Morroco = Morroco = point coverage
Syria = Syria = point coverage
Tunisia = Tunisia = point coverage
Turkey = Turkey = point coverage
Global Mines = Gmines_dcw = point coverage
Europe-Asia_USGS = Eurmine_usgs = point coverage
Europe-Asia_USBM = Eurmines_usbm = point coverage

Novaya_Zemlya_geology.aep
Country Borders = countries_geo = line coverage
Novaya Zemlya = nov_geol = polygon coverage
Barents Sea = bar_tect = line coverage

United_States_geology.aep
Country Borders = countries_geo = line coverage
USGS Faults = usgs_fault = line coverage
US Geology = usgs2_geo = polygon coverage
High Res. Geology = usgs2_geo = line coverage

Volcanoes.aep
Country Borders = countries_geo = line coverage
Global Volcanoes = gvolcanoes = point coverage

World_Geology.aep
Country Borders = countries_geo = line coverage
World Geology = world_dd = polygon coverage

Geophysics

Africa_Middle_East_gravity.aep
Country Borders = countries_geo = line coverage
afr_fair = image
afr_boug = image

China_moho.aep
Country Borders = countries_geo = line coverage
china_moho = image

CMT.aep
Country Borders = countries_geo = line coverage
CMT = cmt-ae= point coverage

ISC.aep
Country Borders = countries_geo = line coverage
ISC = Isc = point coverage

Eurasia_lg_coda_Q.aep
Country Borders = countries_geo = line coverage
Eurasia_lg_coda_Q = image file

Eurasia_moho.aep
Country Borders = countries_geo = line coverage
Eurasia_moho =image file
Eurasia_Error = image file

Global_basement.aep
Country Borders = countries_geo = line coverage
global_basm = image file

Global_moho.aep
Country Borders = countries_geo = line coverage
global_moho = image file

IDC_Events.aep
Country Borders = countries_geo = line coverage
IDC Events = idc-ev = point coverage

IPE_basement.aep
Country Borders = countries_geo = line coverage
IPE_basement = image file

IPE_moho.aep
Country Borders = countries_geo = line coverage
ipe_moho = image file

Middle_East_basement.aep
Country Borders = countries_geo = line coverage
Middle_East_basement= image

Middle_East_hypocenters.aep
Country Borders = countries_geo = line coverage
Hypocenters = hypo_dd = point coverage

Middle_East_moho.aep
Country Borders = countries_geo = line coverage
Middle_East_moho = image file

Moho.aep
Country Borders = countries_geo = line coverage
china_moho = image file
united_states_moho = image file
united_states(error) = image file
middle_east_moho = image file
ipe-moho = image file
russia_moho = image file
russia(no_urals) = image file
russia-urals_moho = image file
global_moho = image file
eurasia-error = image file
eurasia_moho = image file

Novaya_Zemlya.aep
Country Borders = countries_geo = line coverage
eurasia_moho = image file
ipe_basement = image file

ipe-moho = image file
russia-urals_moho = image file
barents Sea = bar_tect = line coverage
Novaya Zemlya = nov_geol = polygon coverage

Russia_moho.aep
Country Borders = countries_geo = line coverage
Russia(no_Urals)= image
Russia_moho = image
Russia-Urals_moho = image

United_States_gravity.aep
Country Borders = countries_geo = line coverage
dnag_grav =image

United_States_magenetics.aep
Country Borders = countries_geo = line coverage
dnag_mag = image

United_States_moho.aep
Country Borders = countries_geo = line coverage
United_States(Error)= image
United_States_moho = image

US_Velocity.aep
Borders = count_ae = line coverage
US_Pn = image
US_Pg = image

World_Stress.aep
Country Borders = countries_geo = line coverage
World Stress = wsm = point coverage

Russia_Velocity.aep
Country Borders = countries_geo = line coverage
Russia PG Arcs = russia_pg = line coverage
Russia PG Poly = russia_pg = polygon coverage
Russia PN Arcs = us_pn = line coverage
Russia PN Poly = us_pn = polygon coverage
Us_pn_L – image
Us_pn_U – image
Russia_PG_L – image
Russia_PG_U – image

Multiple_Datasets

World_geography.aep
Country Borders = countries_geo = line coverage
Nuclear Plants = Nuc_plant = point coverage
Nuclear Tests = Nuclear_test = point coverage
Cities = Cities = point coverage
Railroads = Rroads = line coverage
Roads = Roads = line coverage
Lakes = Lakes = polygon coverage

CDROM 2

CDROM2 contains one master directory CU_Database in which all the data and projects are stored. The CDROM is divided into three directories; imagery, projects, and geophysics. The ISC data coverage is stored in the geophysics directory, imagery are stored in the imagery directory, and project files are stored in the Projects folder.

CU_Database

Imagery

Algeria.tif
Lopnor.tif
Nevada.tif
Novaya_Zemlya.tif
Semipalatinsk.tif

Imagery

Seismicity
ISC = point coverage

Projects

ISC = isc = point coverage
Algeria = image project
Lopnor = image project
Nevada = image project
Novaya_Zemlya = image project
Semipalatinsk = image project

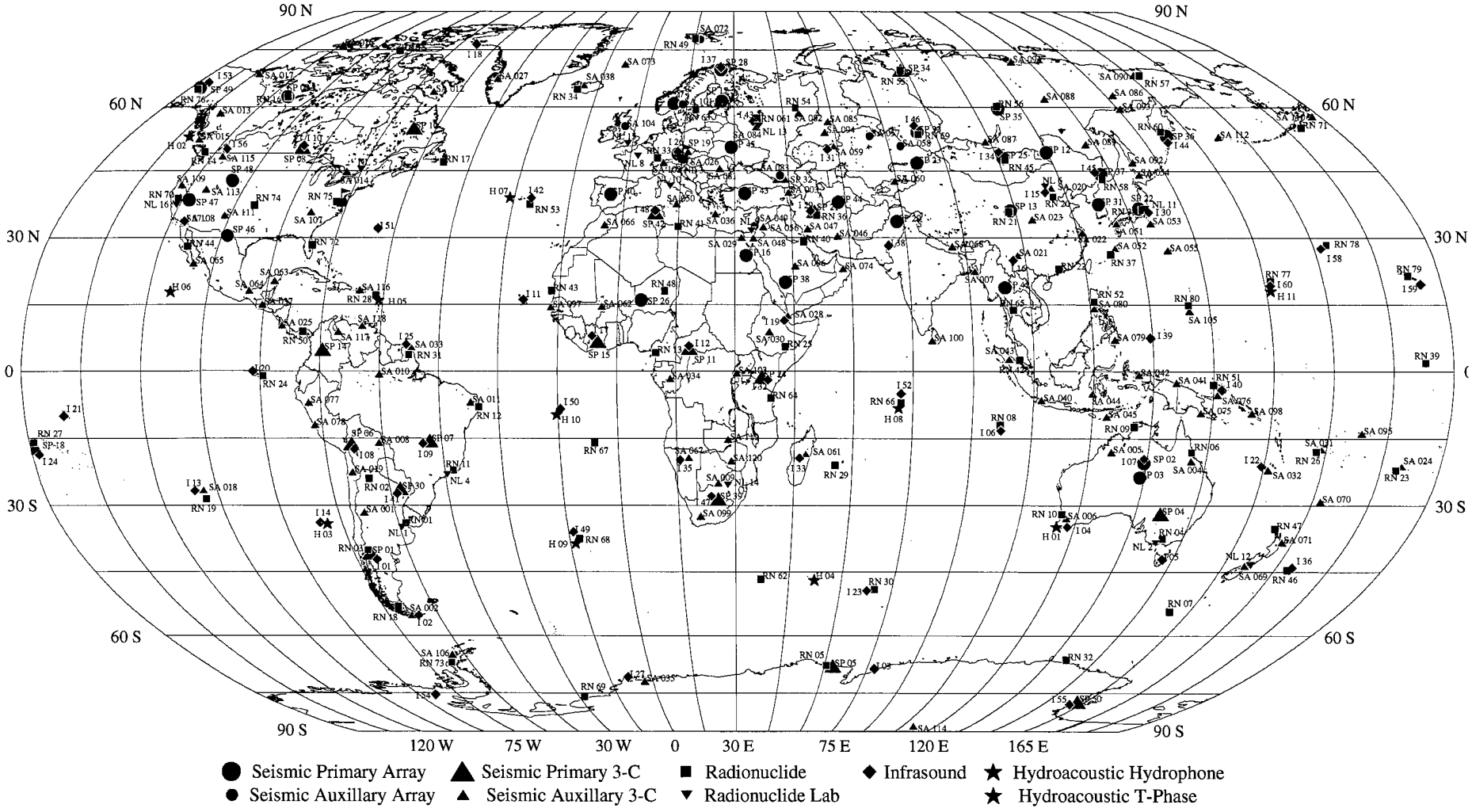

Figure 1. Plotted on this map is the network of sensors that are included in the International Monitoring System for the Comprehensive Test Ban Treaty. Annex 1 to the Protocol to the Treaty lists the required network, which is composed of 50 primary seismic stations, 120 auxilliary seismic stations, 11 hydroacoustic stations, 60 infrasound stations, 80 radionuclide samplers, and 16 radionuclide laboratories.

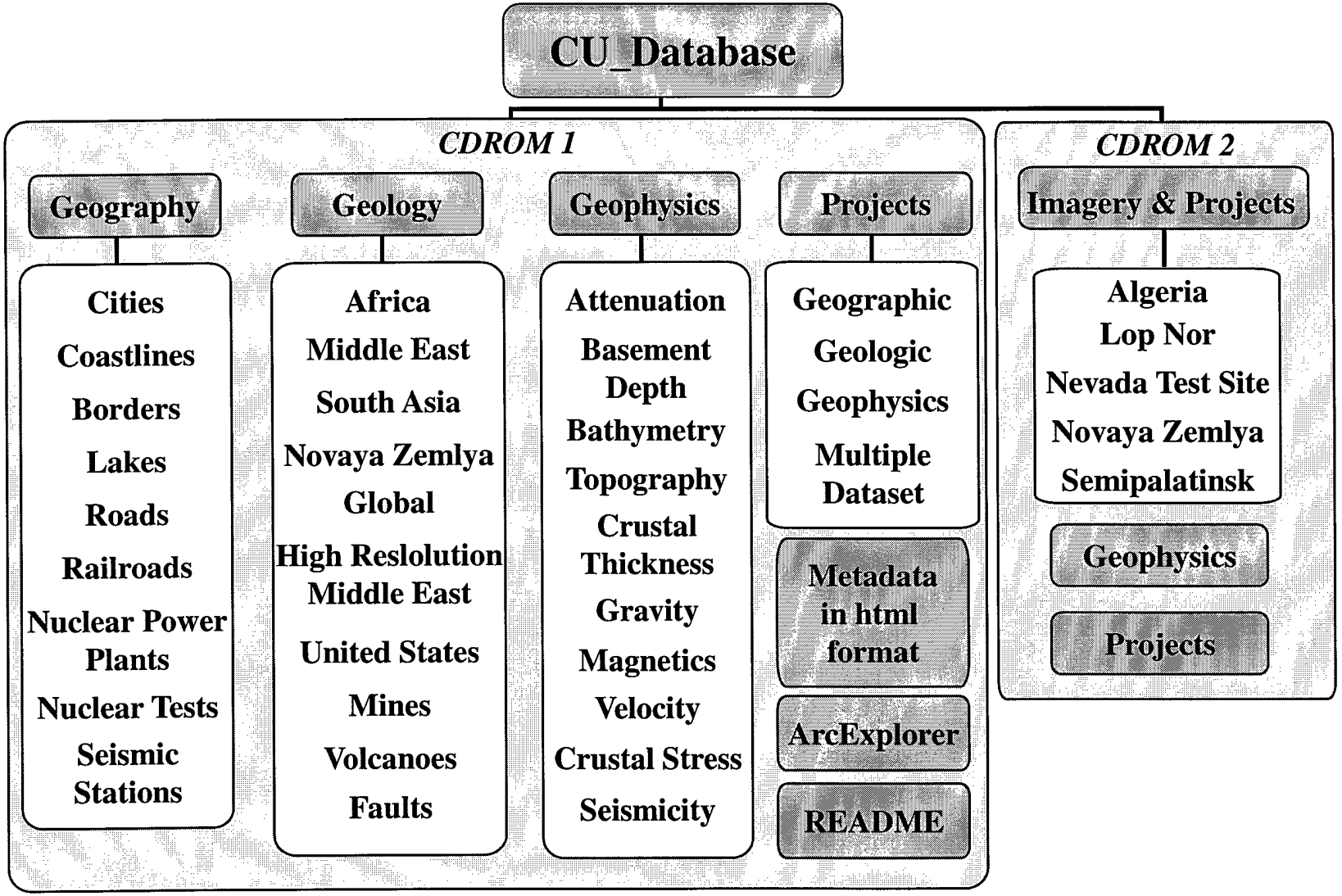

Figure 2. Wire diagram that displays the database structure used for the CDROMs that accompany this report. These data are distributed on two CDROMs, one containing GIS data, the other imagery (and a single geophysics database - the ISC seismicity coverage). The databases on *CDROM 1* are accessed directly through ArcExplorer project files under the appropriate subdirectory in the Projects folder. The images on *CDROM 2* are accessed directly through ArcExplorer project files under the Projects folder. A complete description of the files is available in Appendix A.

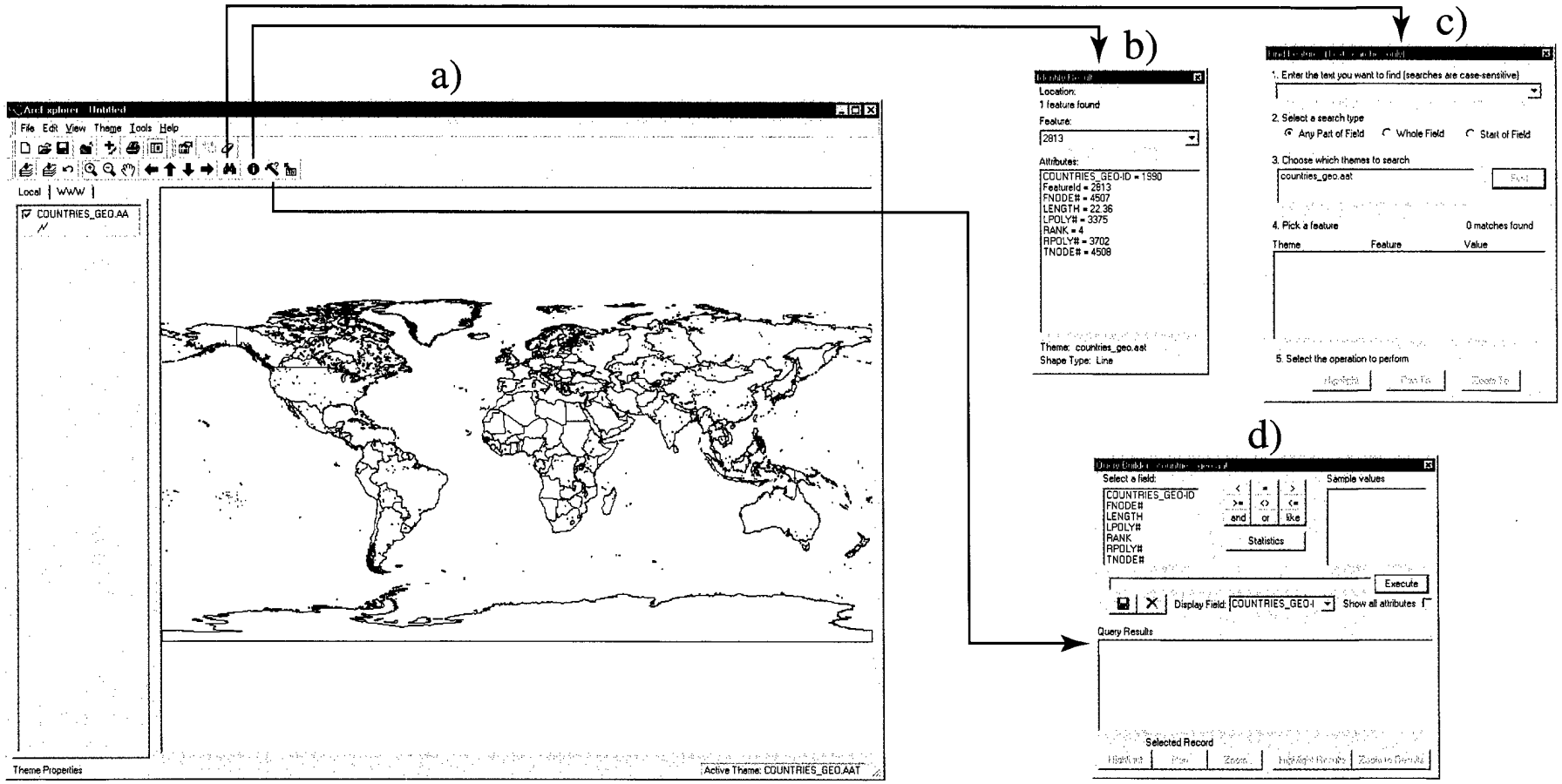

Figure 3. a) Graphical User Interface for ArcExplorer that is used to display the GIS data in the Cornell database. Themes are added by selecting the "+" or Themes Add option. Themes added to a project file appear along the left hand side of the display where they can be toggled on or off. b) Result from using the "Identify" icon and selecting an arc from the active theme. c) Result from the "Select" data option that permits the user to select specific features to display rather than the entire coverage. d) Result from using the "Query" data option that permits the user to complete spatial analyses of the database.

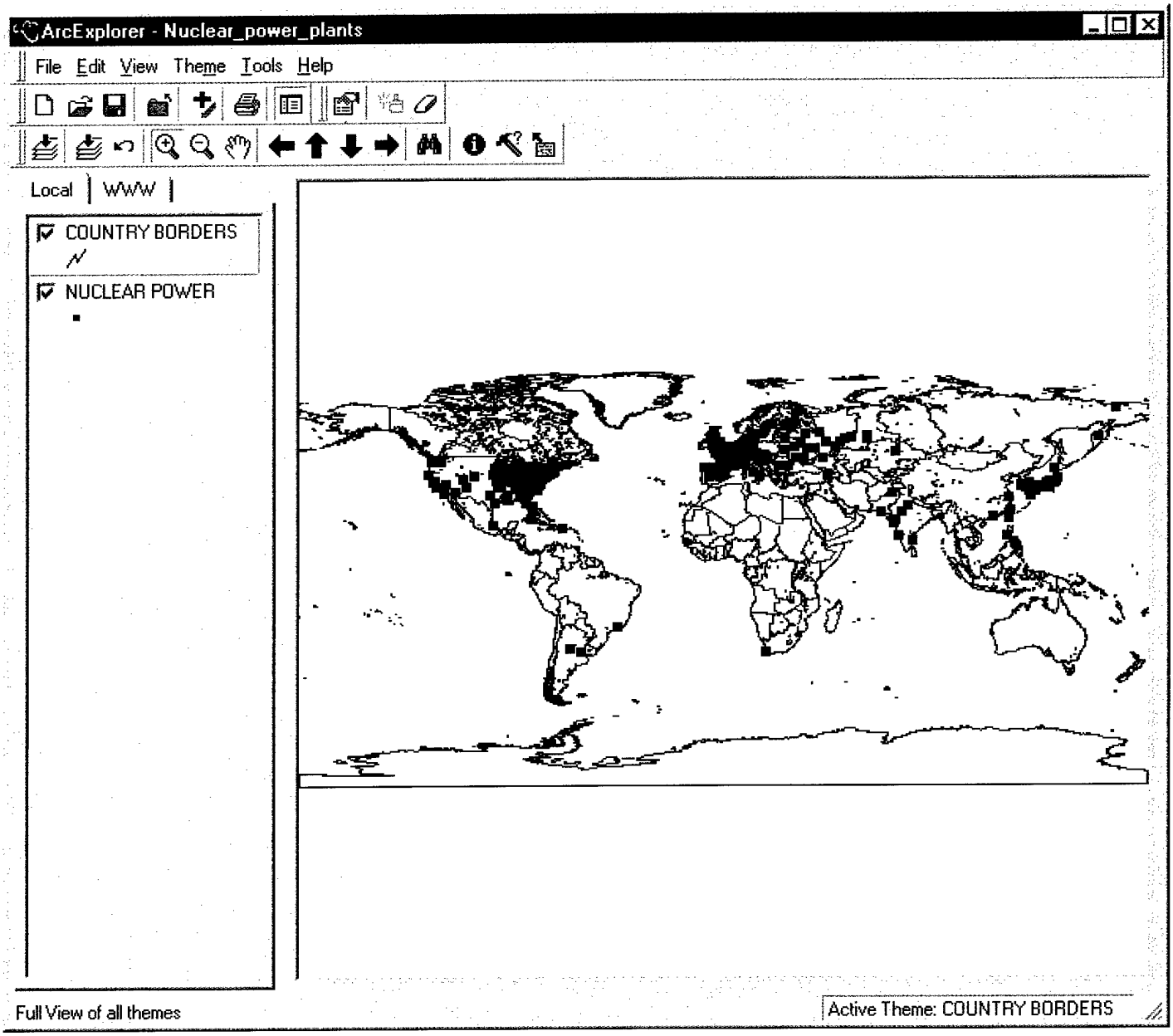

Figure 4. ArcExplorer project displaying the nuclear power plants of the world over the country borders. Attributes for each power plant can be directly accessed by clicking on the theme to make it active and using the "identify" icon to select a point. The locations of producing nuclear power plants may be important for radionuclide monitoring.

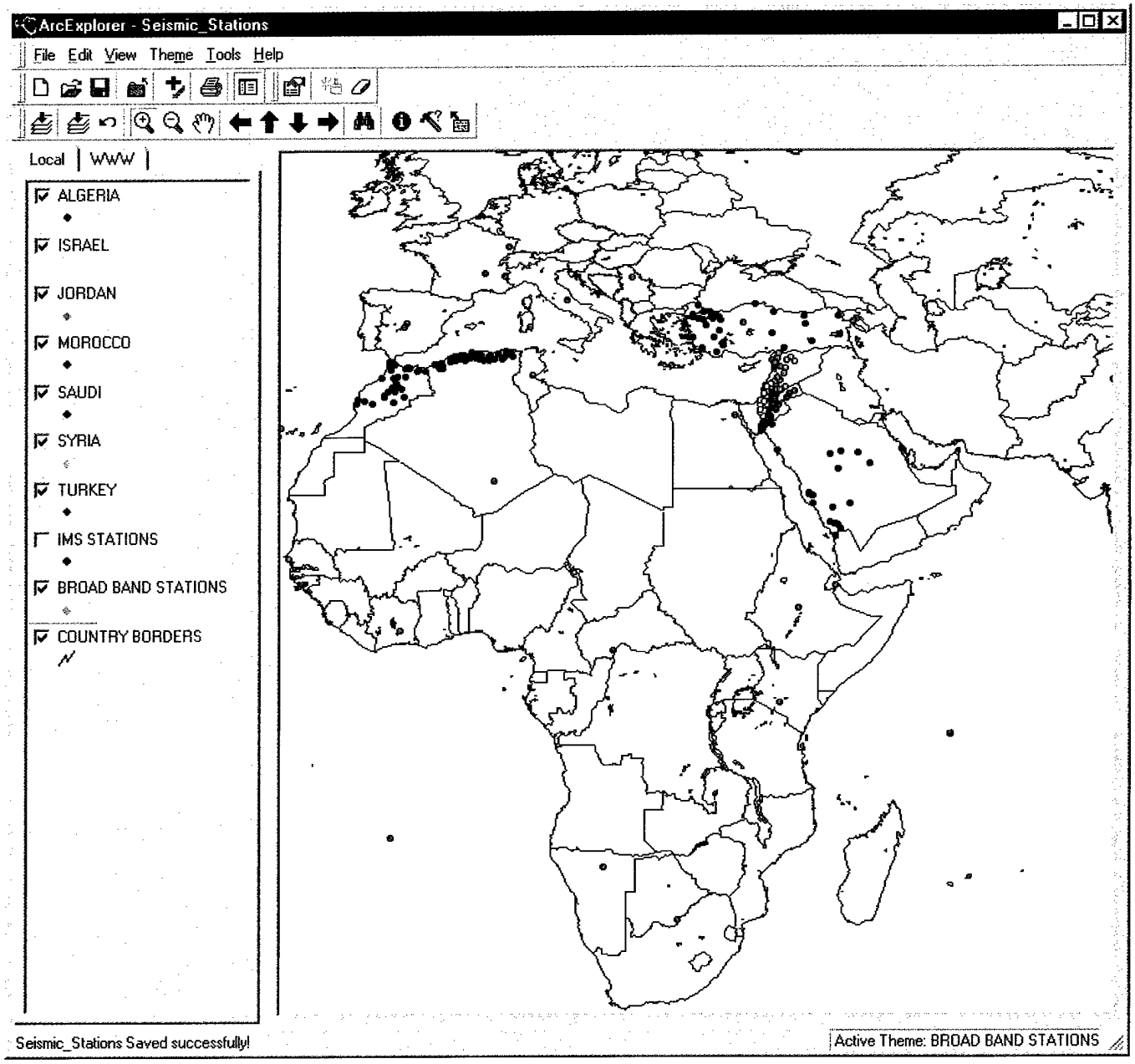

Figure 5. ArcExplorer project displaying the seismic station database for the Middle East and North Africa (excluding the IMS stations). Broadband stations for Africa and southern Europe are also displayed in this image. As shown in the themes section on the left, each country can be assigned a different symbol and color, attributes can be accessed directly on the screen, and various themes can be turned on or off based on the needs of the user.

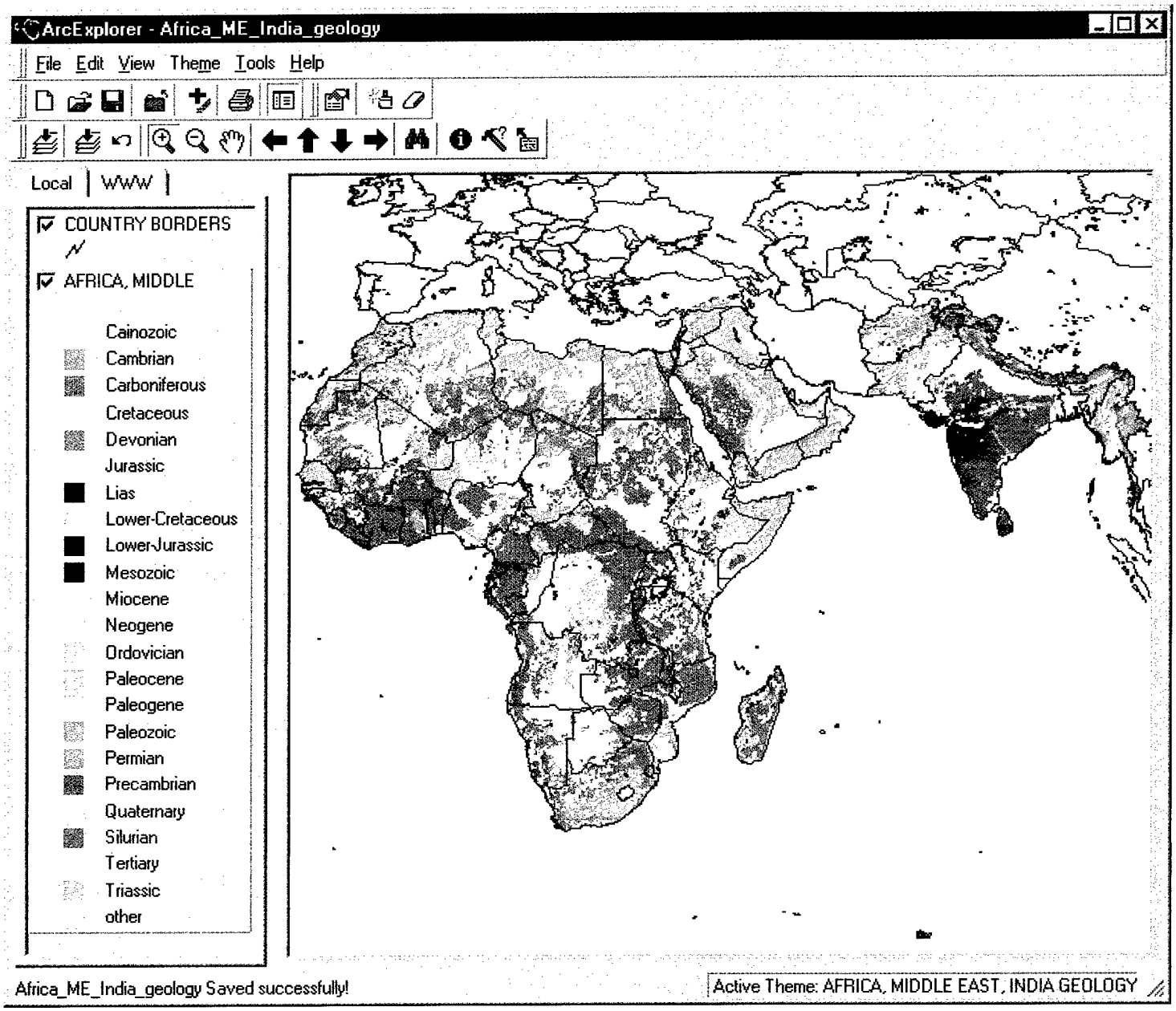

Figure 6. ArcExplorer project displaying the geology map of the Middle East, North Africa, and South Asia from the USGS digital database compiled by Persits et al. (1997), Pollastro et al. (1998), and Wandry and Law (1998). These data are color coded by the age of the geologic unit as shown in the menu at the left. The attributes describing a specific unit and location can be viewed by using the "identify" icon to select a polygon. Colors are selected based on the age of the rock unit.

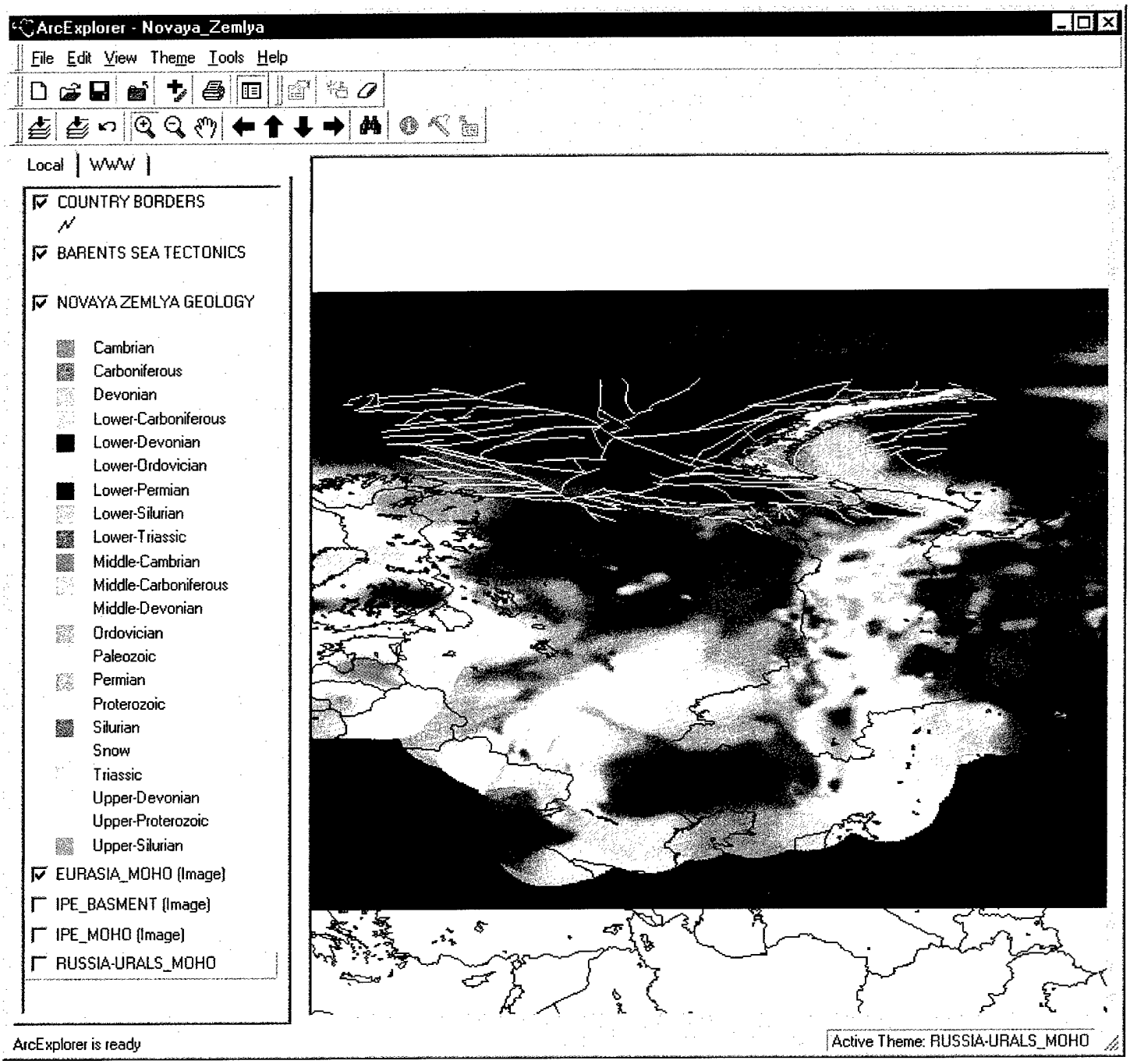

Figure 7. ArcExplorer project displaying datasets complied for a special study of the Novaya Zemlya region. The geology of Novaya Zemlya derived from the 1:2,500,000 geologic map of the USSR is displayed with faults (in white) derived from the work of Bogatsky et al., (1996). The underlying image is of the crustal thickness for Eurasia that was complied using all available crustal thickness data as part of a collaborative study with PIDC scientists Vlad Ryaboy and Robert North.

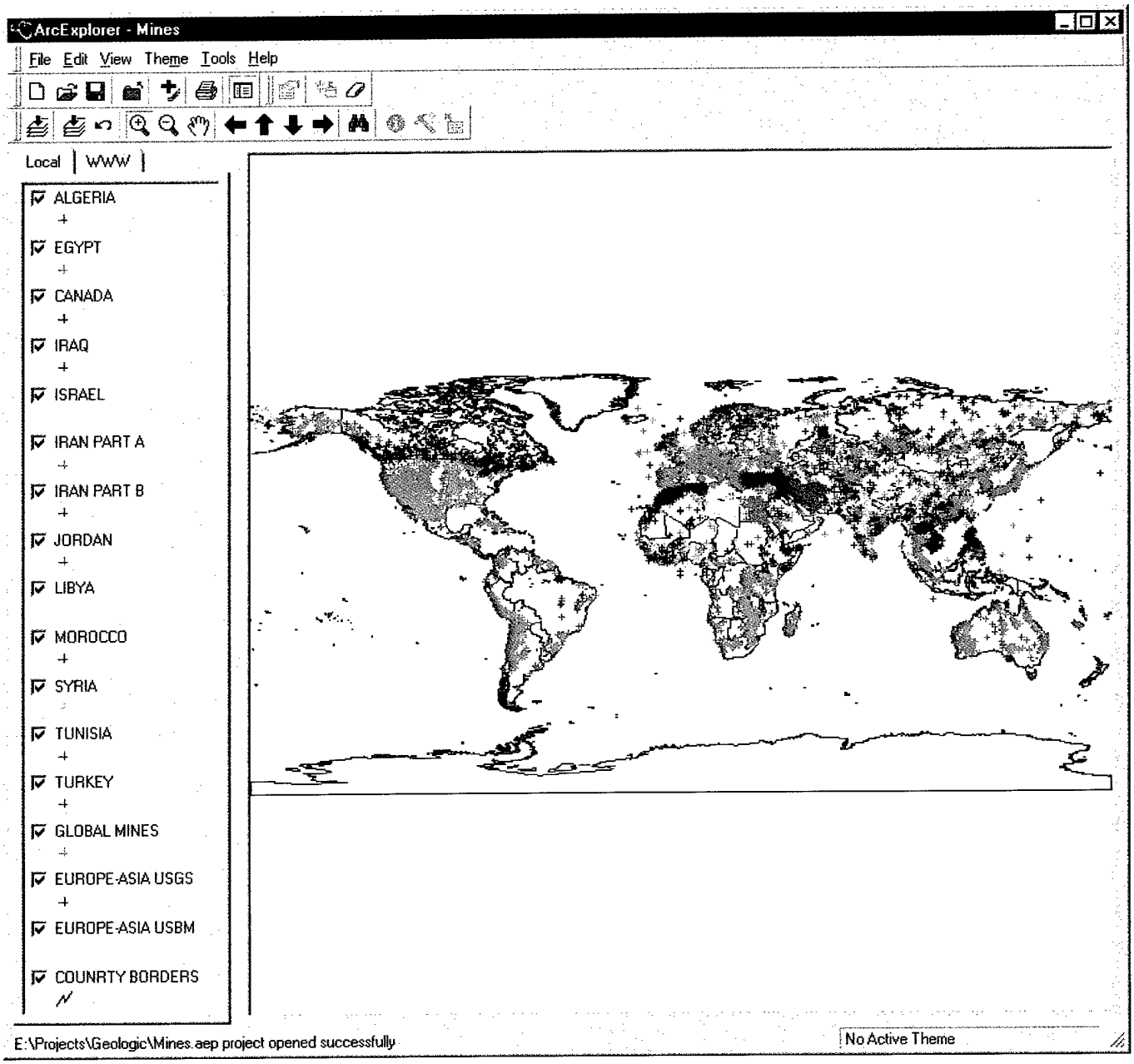

Figure 8. ArcExplorer project displaying the entire mine locations database contained in the Cornell database. This database includes individual country mine locations extracted from DOE and DoD progress reports, regional locations from the USGS and former US Bureau of Mines, the Canadian Geologic Survey, and the Digital Chart of the World.

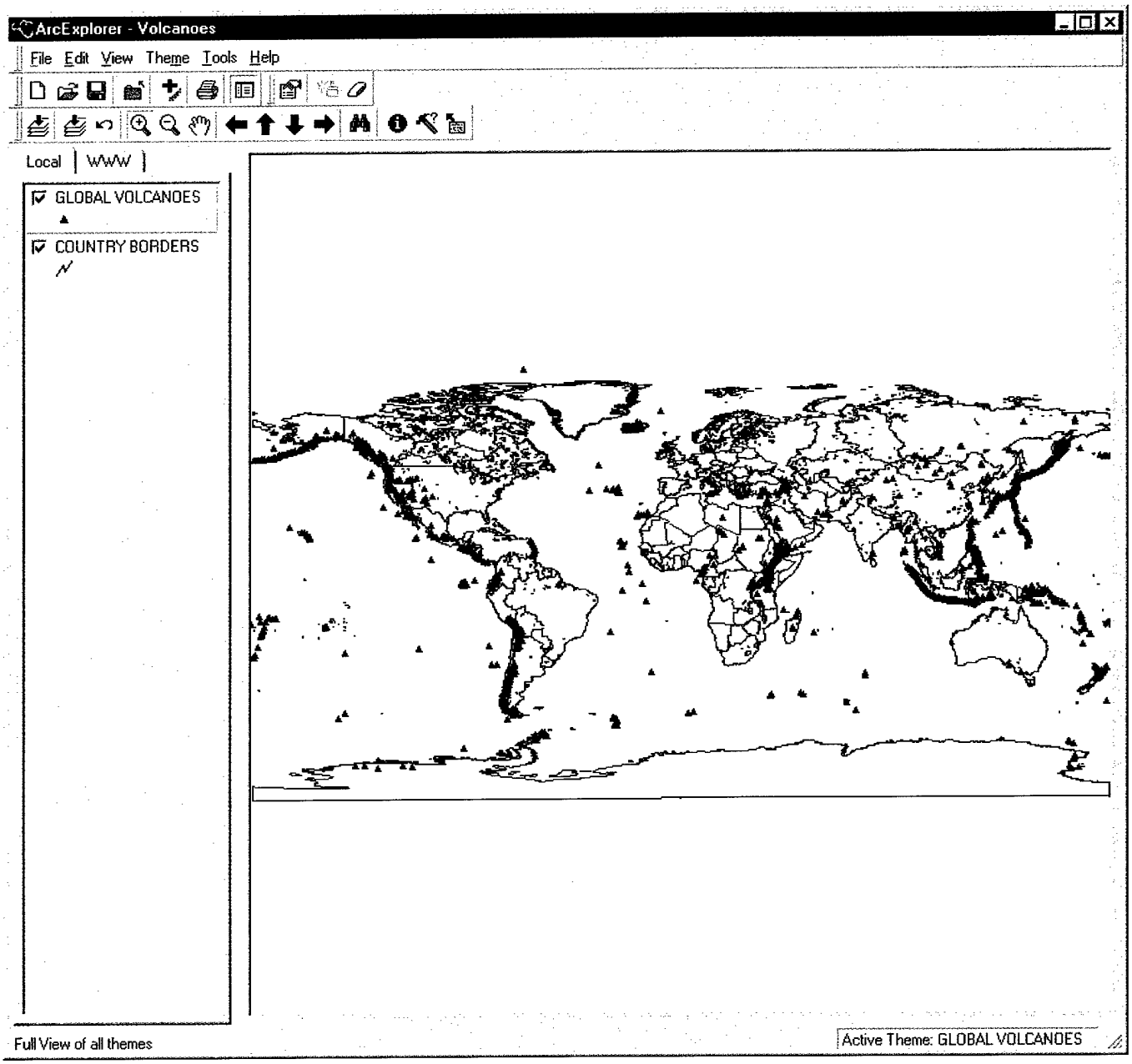

Figure 9. ArcExplorer project displaying the catalog of active volcanoes of the world. These data are essential when analyzing events with explosive characteristics that might occur near one of these volcanic centers or for analyzing sub-marine events. The attributes for any point can be accessed with the "identify" icon. These data include only those volcanic centers that were active within the past 10,000 years.

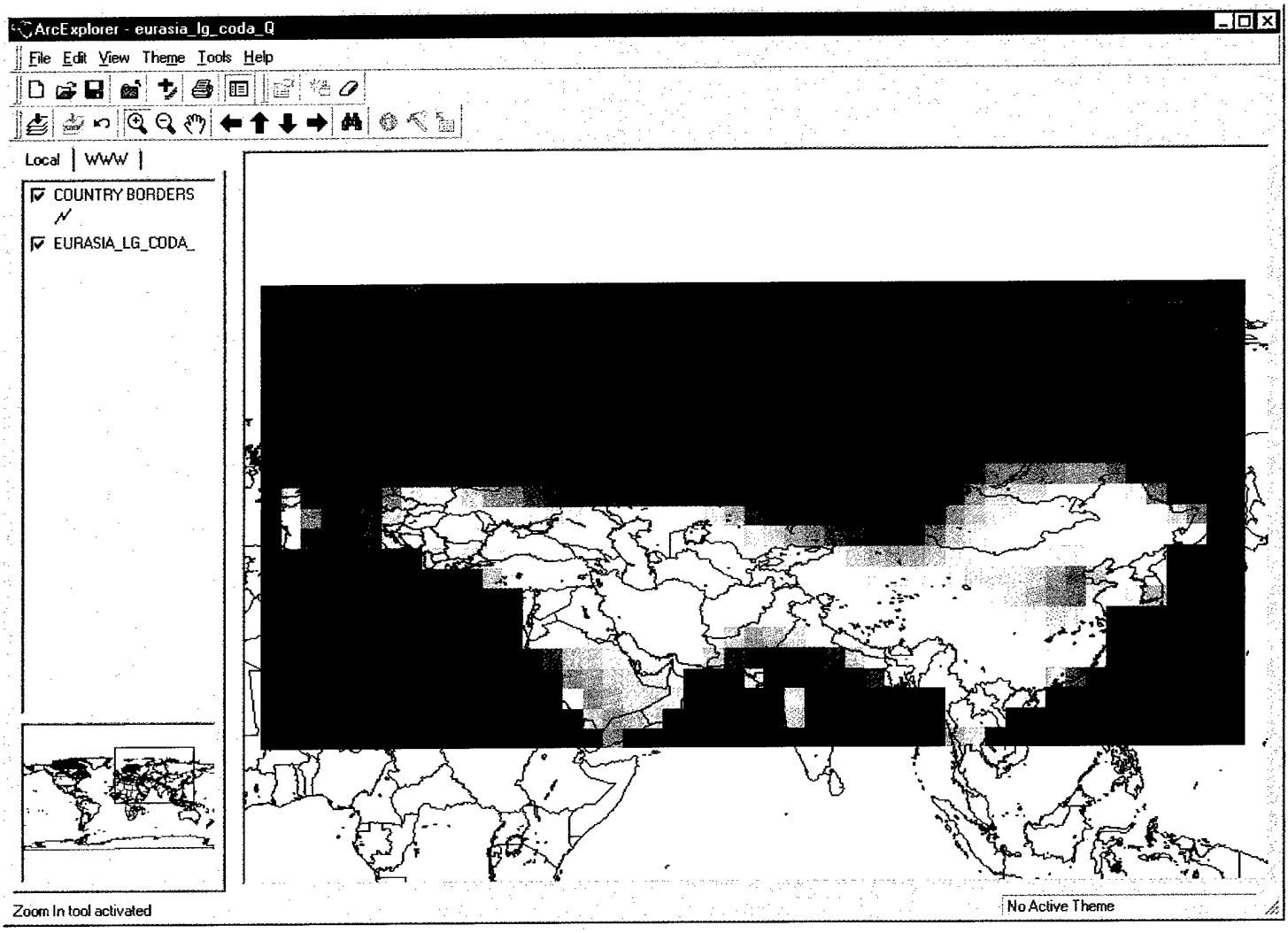

Figure 10. ArcExplorer project displaying the Lg attenuation grid for Europe and Asia from the work of Mitchell et al. (1997). These data are displayed as an image due to data handling limitations of ArcExplorer. Purple colors denote regions of high Q (low attenuation) and yellow colors denote regions of low Q (high attenuation). ASCII files with the original data are included on the CDROM with this image.

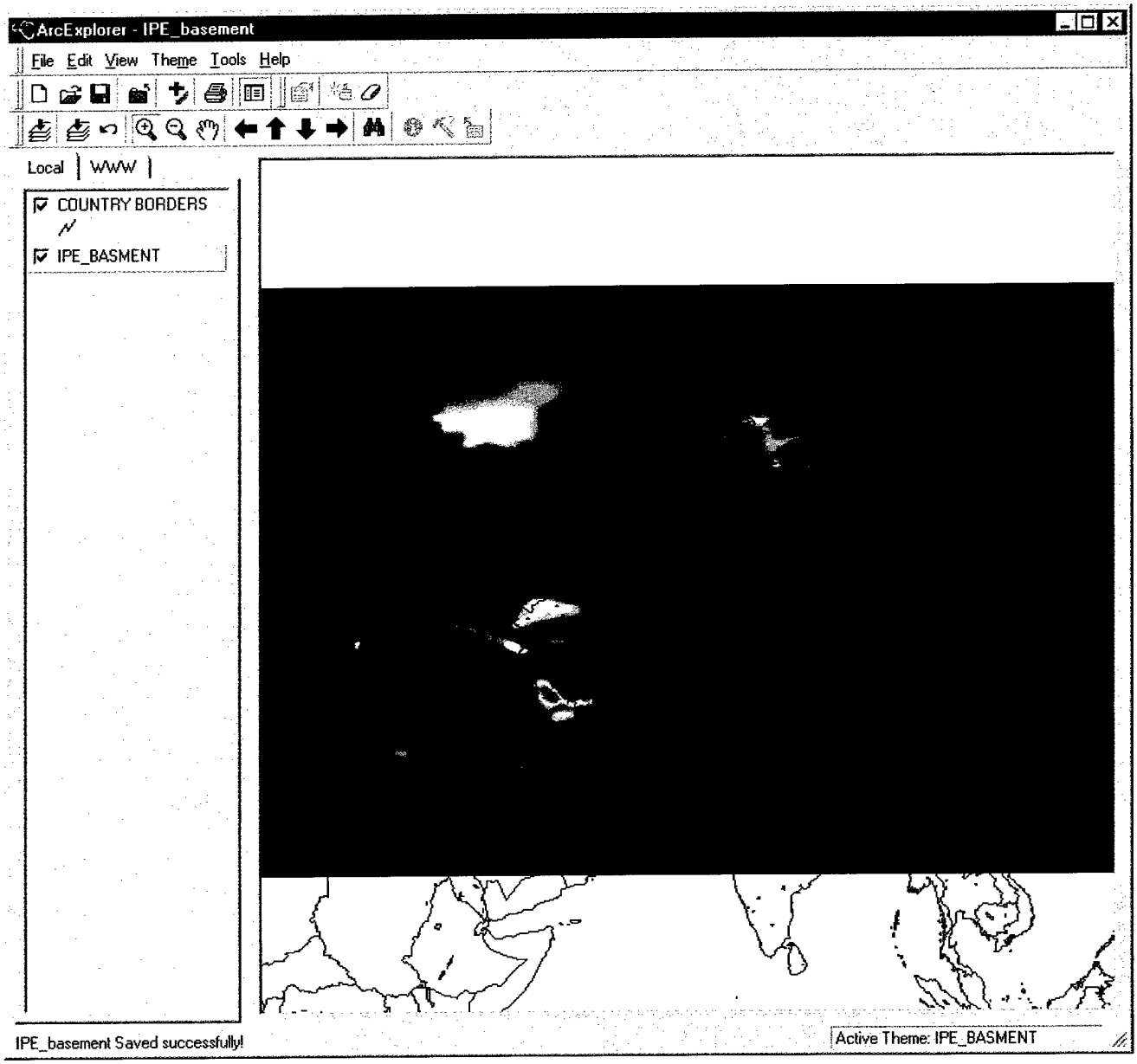

Figure 11. Image of the depth-to-basement grid as derived from the Institute for the Physics of the Earth (IPE) map. The regions in purple denote regions of shallow depth-to-basement and the regions in red denote deeper regions. These data are displayed as images due to data handling limitations inherent to ArcExplorer. The orignal data are included with this image as an ASCII file on the CDROM.

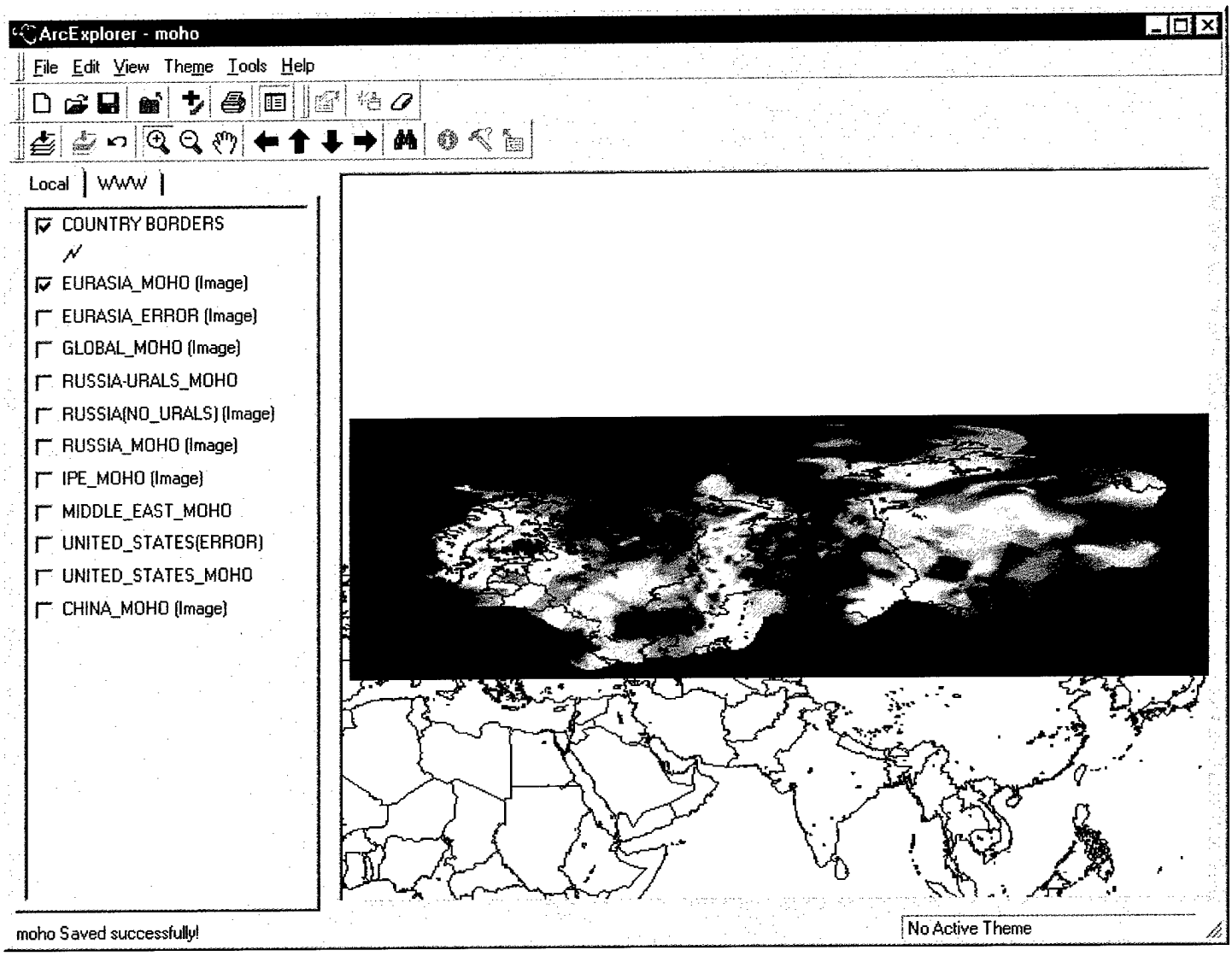

Figure 12. This ArcExplorer project displays an image of the crustal thickness for Eurasia that was derived by combining all available datasets for the region. Blue denotes thin crust (~20 km) while reds denote thick crust (~60 km). Regions in purple contain no data. In the menu to the left are themes with images and error surfaces of the databases used to calculate this combined grid. Individual grids can be toggled on and off to permit visual comparisons of the original databases to the final grid. All databases contained in this project are also included as ASCII files with the images on the CDROM.

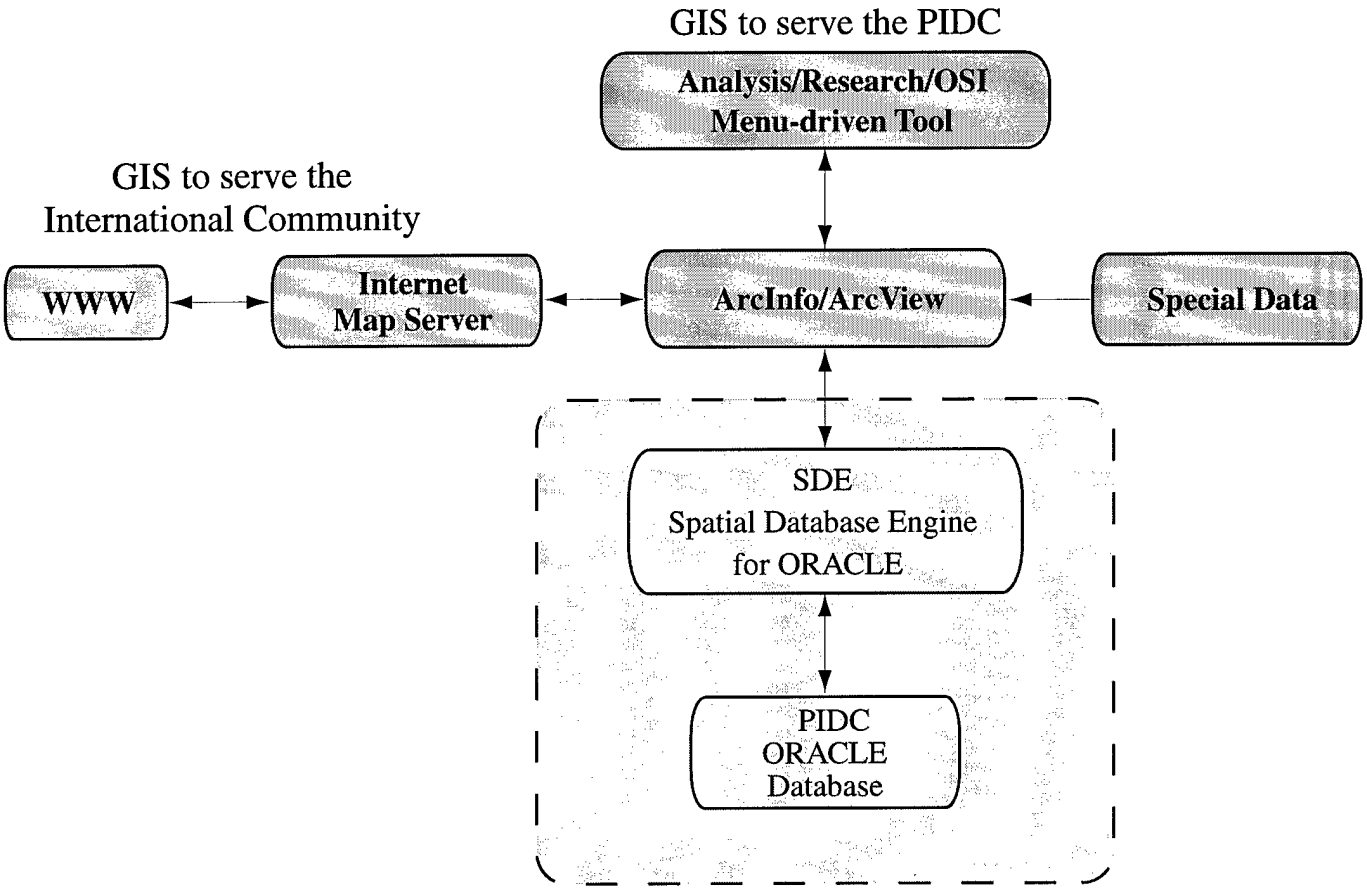

Figure 13. A complete GIS system for the PIDC includes ArcInfo access to special databases (geologic, geophysical, geographical, and imagery) that may not reside in the Oracle database and direct access to the PIDC Oracle database through a spatial database engine (SDE). Additionally, to better serve US transparency interests, a publically accessible map server can be added for use over the World Wide Web. Those portions of the diagram outside of the dashed box are fully functional and operational at Cornell. Addition of SDE connections to the Oracle database will require both the software and database write permissions required to modify tables to create SDE shape files.